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# ACM TEMPLATE

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# 1 To Do List

测试DC3模板。。

所有带\*的内容。。。

可以从原来的模板里面继承一些好东西过来。

set,map,multiset等的搞基用法，以及注意事项。

## 2 注意事项

$10^6$ 数量级慎用后缀数组

TLE的时候要冷静哟。。

7k+的图计数 (Wc2012的communication)

思考的时候结合具体步骤来的话 会体会到一些不同的东西

C++与G++是很不一样的。。。

map套字符串是很慢的。。。

栈会被记录内存。。。

浮点数最短路要注意取 $\leq$ 来判断更新。。。

注意 long long

不要相信.size()

重复利用数组时 小心数组范围

先构思代码框架 每当实际拍马框架变化时 停手 重新思考

有时候四边形不等式也是帮得上忙的 dp 优化是可以水的

结构体里面带数组会非常慢,有时候 BFS 把数组压成数字会快很多。

```
1 | void fun(int a[])
2 | {
3 |     printf("%d\n", sizeof(a));
4 | }
```

结果是 sizeof(a[0]),如果传数组指针然后要清空的话不要用 sizeof。

sqrt 某些时候会出现 sqrt(-0.00)的问题。

将code::blocks的默认终端改成gnome-terminal

```
1 | gnome-terminal -t $TITLE -x
```

## 3 字符串处理

### 3.1 \*AC自动机

#### 3.1.1 指针

```
1  const int CHAR=26;
2  const int TOTLEN=500000;
3  const int MAXLEN=1000000;
4  struct Vertex
5  {
6      Vertex *fail,*next[CHAR];
7      Vertex(){}
8      Vertex(bool flag)//为什么要这样写?
9      {
10         fail=0;
11         memset(next,0,sizeof(next));
12     }
13 };
14 int size;
15 Vertex vertex[TOTLEN+1];
16 void init()
17 {
18     vertex[0]=Vertex(0);
19     size=1;
20 }
21 void add(Vertex *pos,int cha)
22 {
23     vertex[size]=Vertex(0);
24     pos->next[cha]=&vertex[size++];
25 }
26 void add(vector<int> s)
27 {
28     int l=s.size();
29     Vertex *pos=&vertex[0];
30     for (int i=0; i<l; i++)
31     {
32         if (pos->next[s[i]]==NULL)
33             add(pos,s[i]);
34         pos=pos->next[s[i]];
35     }
36 }
37 void bfs()
38 {
39     queue<Vertex *> que;
40     Vertex *u=&vertex[0];
41     for (int i=0; i<CHAR; i++)
42         if (u->next[i]!=NULL)
43         {
44             que.push(u->next[i]);
45             u->next[i]->fail=u;
46         }
47         else
48             u->next[i]=u;
49     u->fail=NULL;
50     while (!que.empty())
51     {
52         u=que.front();
53         que.pop();
54         for (int i=0; i<CHAR; i++)
55             if (u->next[i]!=NULL)
56             {
57                 que.push(u->next[i]);
```

```

58         u->next[i]->fail=u->fail->next[i];
59     }
60     else
61         u->next[i]=u->fail->next[i];
62 }
63 }

```

### 3.1.2 非指针

```

1  struct Trie
2  {
3      int next[50][10],fail[50];
4      bool end[50];
5      int L,root;
6
7      int newNode()
8      {
9          for (int i = 0;i < 10;i++)
10             next[L][i] = -1;
11             end[L] = false;
12             return L++;
13     }
14
15     void Init()
16     {
17         L = 0;
18         root = newNode();
19     }
20
21     void Insert(char s[])
22     {
23         int now = root;
24         for (int i = 0;s[i] != 0;i++)
25         {
26             if (next[now][s[i]-'0'] == -1)
27                 next[now][s[i]-'0'] = newNode();
28             now = next[now][s[i]-'0'];
29         }
30         end[now] = true;
31     }
32
33     void Build()
34     {
35         queue<int> Q;
36         for (int i = 0;i < 10;i++)
37             if (next[root][i] == -1)
38                 next[root][i] = root;
39             else
40             {
41                 fail[next[root][i]] = root;
42                 Q.push(next[root][i]);
43             }
44         while (!Q.empty())
45         {
46             int now = Q.front();
47             Q.pop();
48             end[now] |= end[fail[now]];
49             for (int i = 0;i < 10;i++)
50                 if (next[now][i] == -1)
51                     next[now][i] = next[fail[now]][i];
52                 else
53                 {
54                     fail[next[now][i]] = next[fail[now]][i];
55                     Q.push(next[now][i]);

```

```

56         }
57     }
58 }
59 };

```

## 3.2 后缀数组

### 3.2.1 DC3

所有下标都是0 n-1, height[0]无意义。

```

1 //所有相关数组都要开三倍
2 const int maxn = 300010;
3 # define F(x) ((x)/3+((x)%3==1?0:tb))
4 # define G(x) ((x)<tb?(x)*3+1:((x)-tb)*3+2)
5 int wa[maxn * 3], wb[maxn * 3], wv[maxn * 3], ws[maxn * 3];
6 int c0(int *r, int a, int b)
7 {
8     return r[a] == r[b] && r[a + 1] == r[b + 1] && r[a + 2] == r[b + 2];
9 }
10 int c12(int k, int *r, int a, int b)
11 {
12     if (k == 2) return r[a] < r[b] || r[a] == r[b] && c12(1, r, a + 1, b + 1);
13     else return r[a] < r[b] || r[a] == r[b] && wv[a + 1] < wv[b + 1];
14 }
15 void sort(int *r, int *a, int *b, int n, int m)
16 {
17     int i;
18     for (i = 0; i < n; i++) wv[i] = r[a[i]];
19     for (i = 0; i < m; i++) ws[i] = 0;
20     for (i = 0; i < n; i++) ws[wv[i]]++;
21     for (i = 1; i < m; i++) ws[i] += ws[i - 1];
22     for (i = n - 1; i >= 0; i--) b[--ws[wv[i]]] = a[i];
23     return;
24 }
25 void dc3(int *r, int *sa, int n, int m)
26 {
27     int i, j, *rn = r + n, *san = sa + n, ta = 0, tb = (n + 1) / 3, tbc = 0,
        p;
28     r[n] = r[n + 1] = 0;
29     for (i = 0; i < n; i++) if (i % 3 != 0) wa[tbc++] = i;
30     sort(r + 2, wa, wb, tbc, m);
31     sort(r + 1, wb, wa, tbc, m);
32     sort(r, wa, wb, tbc, m);
33     for (p = 1, rn[F(wb[0])] = 0, i = 1; i < tbc; i++)
34         rn[F(wb[i])] = c0(r, wb[i - 1], wb[i]) ? p - 1 : p++;
35     if (p < tbc) dc3(rn, san, tbc, p);
36     else for (i = 0; i < tbc; i++) san[rn[i]] = i;
37     for (i = 0; i < tbc; i++) if (san[i] < tb) wb[ta++] = san[i] * 3;
38     if (n % 3 == 1) wb[ta++] = n - 1;
39     sort(r, wb, wa, ta, m);
40     for (i = 0; i < tbc; i++) wv[wb[i] = G(san[i])] = i;
41     for (i = 0, j = 0, p = 0; i < ta && j < tbc; p++)
42         sa[p] = c12(wb[j] % 3, r, wa[i], wb[j]) ? wa[i++] : wb[j++];
43     for (; i < ta; p++) sa[p] = wa[i++];
44     for (; j < tbc; p++) sa[p] = wb[j++];
45 }
46 //str和sa也要三倍
47 void da(int str[], int sa[], int rank[], int height[], int n, int m)
48 {
49     for (int i = n; i < n * 3; i++)
50         str[i] = 0;
51     dc3 (str , sa , n + 1 , m);
52     int i, j, k;

```



```

53     for (i = 0; i < n; i++)
54     {
55         sa[i] = sa[i + 1];
56         rank[sa[i]] = i;
57     }
58     for (i = 0, j = 0, k = 0; i < n; height[rank[i++]] = k)
59         if (rank[i] > 0)
60             for (k ? k-- : 0, j = sa[rank[i] - 1]; i + k < n && j + k < n
61                 &&
62                     str[i + k] == str[j + k]; k++) ;

```

### 3.2.2 DA

这份似乎就没啥要注意的了。

```

1  const int maxn = 200010;
2  int wx[maxn],wy[maxn],*x,*y,wss[maxn],wv[maxn];
3
4  bool cmp(int *r,int n,int a,int b,int l)
5  {
6      return a+l<n && b+l<n && r[a]==r[b]&&r[a+l]==r[b+l];
7  }
8  void da(int str[],int sa[],int rank[],int height[],int n,int m)
9  {
10     int *s = str;
11     int *x=wx,*y=wy,*t,p;
12     int i,j;
13     for(i=0; i<m; i++)wss[i]=0;
14     for(i=0; i<n; i++)wss[x[i]=s[i]]++;
15     for(i=1; i<m; i++)wss[i]+=wss[i-1];
16     for(i=n-1; i>=0; i--)sa[--wss[x[i]]]=i;
17     for(j=1,p=1; p<n && j<n; j*=2,m=p)
18     {
19         for(i=n-j,p=0; i<n; i++)y[p++]=i;
20         for(i=0; i<n; i++)if(sa[i]-j>=0)y[p++]=sa[i]-j;
21         for(i=0; i<n; i++)wv[i]=x[y[i]];
22         for(i=0; i<m; i++)wss[i]=0;
23         for(i=0; i<n; i++)wss[wv[i]]++;
24         for(i=1; i<m; i++)wss[i]+=wss[i-1];
25         for(i=n-1; i>=0; i--)sa[--wss[wv[i]]]=y[i];
26         for(t=x,x=y,y=t,p=1,i=1,x[sa[0]]=0; i<n; i++)
27             x[sa[i]]=cmp(y,n,sa[i-1],sa[i],j)?p-1:p++;
28     }
29     for(int i=0; i<n; i++) rank[sa[i]]=i;
30     for(int i=0,j=0,k=0; i<n; height[rank[i++]]=k)
31         if(rank[i]>0)
32             for(k?k--:0,j=sa[rank[i]-1]; i+k < n && j+k < n && str[i+k]==str
33                 [j+k]; k++);

```

## 3.3 后缀三兄弟

```

1  #include <cstdio>
2  #include <cstring>
3  #include <algorithm>
4  using namespace std;
5  const int CHAR = 26;
6  const int MAXN = 100000;
7  struct SAM_Node
8  {
9      SAM_Node *fa,*next[CHAR];
10     int len;

```

```

11     int id,pos;
12     SAM_Node() {}
13     SAM_Node(int _len)
14     {
15         fa = 0;
16         len = _len;
17         memset(next,0,sizeof(next));
18     }
19 };
20 SAM_Node SAM_node[MAXN * 2], *SAM_root, *SAM_last;
21 int SAM_size;
22 SAM_Node *newSAM_Node(int len)
23 {
24     SAM_node[SAM_size] = SAM_Node(len);
25     SAM_node[SAM_size].id=SAM_size;
26     return &SAM_node[SAM_size++];
27 }
28 SAM_Node *newSAM_Node(SAM_Node *p)
29 {
30     SAM_node[SAM_size] = *p;
31     SAM_node[SAM_size].id=SAM_size;
32     return &SAM_node[SAM_size++];
33 }
34 void SAM_init()
35 {
36     SAM_size = 0;
37     SAM_root = SAM_last = newSAM_Node(0);
38     SAM_node[0].pos=0;
39 }
40 void SAM_add(int x,int len)
41 {
42     SAM_Node *p = SAM_last, *np = newSAM_Node(p->len + 1);
43     np->pos=len;
44     SAM_last = np;
45     for (; p && !p->next[x]; p = p->fa)
46         p->next[x] = np;
47     if (!p)
48     {
49         np->fa = SAM_root;
50         return ;
51     }
52     SAM_Node *q = p->next[x];
53     if (q->len == p->len + 1)
54     {
55         np->fa = q;
56         return ;
57     }
58     SAM_Node *nq = newSAM_Node(q);
59     nq->len = p->len + 1;
60     q->fa = nq;
61     np->fa = nq;
62     for (; p && p->next[x] == q; p = p->fa)
63         p->next[x] = nq;
64 }
65 void SAM_build(char *s)
66 {
67     SAM_init();
68     int l = strlen(s);
69     for (int i = 0; i < l; i++)
70         SAM_add(s[i] - 'a',i+1);
71 }
72
73 SAM_Node * SAM_add(SAM_Node *p, int x, int len)

```

```

74 {
75     SAM_Node *np = newSAM_Node(p->len + 1);
76     np->pos = len;
77     SAM_last = np;
78     for (; p && !p->next[x]; p = p->fa)
79         p->next[x] = np;
80     if (!p)
81     {
82         np->fa = SAM_root;
83         return np;
84     }
85     SAM_Node *q = p->next[x];
86     if (q->len == p->len + 1)
87     {
88         np->fa = q;
89         return np;
90     }
91     SAM_Node *nq = newSAM_Node(q);
92     nq->len = p->len + 1;
93     q->fa = nq;
94     np->fa = nq;
95     for (; p && p->next[x] == q; p = p->fa)
96         p->next[x] = nq;
97     return np;
98 }
99 void SAM_build(char *s)//多串建立 注意SAM_init()的调用
100 {
101     int l = strlen(s);
102     SAM_Node *p = SAM_root;
103     for (int i = 0; i < l; i++)
104     {
105         if (!p->next[s[i] - 'a'] || !(p->next[s[i] - 'a']->len == i + 1))
106             p = SAM_add(p, s[i] - 'a', i + 1);
107         else
108             p = p->next[s[i] - 'a'];
109     }
110 }
111
112 struct ST_Node
113 {
114     ST_Node *next[CHAR], *fa;
115     int len, pos;
116 } ST_node[MAXN*2], *ST_root;
117 int Sufpos[MAXN];
118 void ST_add(int u, int v, int chr, int len)
119 {
120     ST_node[u].next[chr] = &ST_node[v];
121     ST_node[v].len = len;
122 }
123 void init(int n)
124 {
125     for (int i = 0; i < n; i++)
126     {
127         ST_node[i].pos = -1;
128         ST_node[i].fa = 0;
129         memset(ST_node[i].next, 0, sizeof(ST_node[i].next));
130     }
131     ST_node[0].pos = 0;
132     ST_root = &ST_node[0];
133 }
134 void ST_build(char *s)
135 {
136     int n = strlen(s);

```

```

137     reverse(s,s+n);
138     SAM_build(s);
139     init(SAM_size);
140     for (int i=1;i<SAM_size;i++)
141     {
142         ST_add(SAM_node[i].fa->id,SAM_node[i].id,s[SAM_node[i].pos-SAM_node[
            i].fa->len-1]-'a',SAM_node[i].len-SAM_node[i].fa->len);
143         if (SAM_node[i].pos==SAM_node[i].len)
144         {
145             Sufpos[n-SAM_node[i].pos+1]=i;
146             ST_node[i].pos=n-SAM_node[i].pos+1;
147         }
148     }
149 }
150
151 int rank[MAXN],sa[MAXN+1];
152 int height[MAXN];
153 int L;
154 void ST_dfs(ST_Node *p)
155 {
156     if (p->pos!=-1)
157         sa[L++]=p->pos;
158     for (int i=0;i<CHAR;i++)
159         if (p->next[i])
160             ST_dfs(p->next[i]);
161 }
162 char s[MAXN+1];
163 int main()
164 {
165     gets(s);
166     ST_build(s);
167     L=0;
168     ST_dfs(ST_root);
169     int n=strlen(s);
170     for (int i=0; i<n; i++)
171         sa[i]=sa[i+1]-1;
172     for (int i=0; i<n; i++)
173         rank[sa[i]]=i;
174     reverse(s,s+n);
175     for (int i=0,j=0,k=0; i<n; height[rank[i++]]=k)
176         if (rank[i])
177             for (k?k--:0,j=sa[rank[i]-1]; s[i+k]==s[j+k]; k++);
178 }

```

### 3.3.1 例题

```

1  #include <iostream>
2  #include <algorithm>
3  #include <cstdio>
4  #include <cstring>
5  using namespace std;
6
7  const int CHAR = 26;
8  const int MAXN = 100000;
9
10 struct SAM_Node
11 {
12     SAM_Node *fa,*next[CHAR];
13     int len;
14     int id;
15     int mat[9];
16     SAM_Node() {}
17     SAM_Node(int _len)
18     {

```

```

19         fa = 0;
20         len = _len;
21         memset(mat,0,sizeof(mat));
22         memset(next,0,sizeof(next));
23     }
24 };
25 SAM_Node SAM_node[MAXN*2],*SAM_root,*SAM_last;
26 int SAM_size;
27 SAM_Node *newSAM_Node(int len)
28 {
29     SAM_node[SAM_size] = SAM_Node(len);
30     SAM_node[SAM_size].id = SAM_size;
31     return &SAM_node[SAM_size++];
32 }
33 SAM_Node *newSAM_Node(SAM_Node *p)
34 {
35     SAM_node[SAM_size] = *p;
36     SAM_node[SAM_size].id = SAM_size;
37     return &SAM_node[SAM_size++];
38 }
39 void SAM_init()
40 {
41     SAM_size = 0;
42     SAM_root = SAM_last = newSAM_Node(0);
43 }
44 void SAM_add(int x,int len)
45 {
46     SAM_Node *p = SAM_last,*np = newSAM_Node(p->len+1);
47     SAM_last = np;
48     for (; p&&!p->next[x]; p=p->fa)
49         p->next[x] = np;
50     if (!p)
51     {
52         np->fa = SAM_root;
53         return;
54     }
55     SAM_Node *q = p->next[x];
56     if (q->len == p->len+1)
57     {
58         np->fa = q;
59         return;
60     }
61     SAM_Node *nq = newSAM_Node(q);
62     nq->len = p->len+1;
63     q->fa = nq;
64     np->fa = nq;
65     for (; p&&p->next[x] == q; p = p->fa)
66         p->next[x] = nq;
67 }
68 int getid(char ch)
69 {
70     return ch-'a';
71 }
72 void SAM_build(char *s)
73 {
74     SAM_init();
75     int l = strlen(s);
76     for (int i = 0; i < l; i++)
77         SAM_add(getid(s[i]),i+1);
78 }
79 char s[10][MAXN+1];
80 int ans;
81 int head[MAXN*2];

```

```

82 struct Edge
83 {
84     int to,next;
85 } edge[MAXN*2];
86 int M;
87 int n;
88 void add_edge(int u,int v)
89 {
90     edge[M].to=v;
91     edge[M].next=head[u];
92     head[u]=M++;
93 }
94 void dfs(int u)
95 {
96     for (int i=head[u]; i!=-1; i=edge[i].next)
97     {
98         int v=edge[i].to;
99         dfs(v);
100         for (int j=0; j<n-1; j++)
101             SAM_node[u].mat[j]=max(SAM_node[v].mat[j],SAM_node[u].mat[j]);
102     }
103     int tmp=SAM_node[u].len;
104     for (int i=0; i<n-1; i++)
105         tmp=min(tmp,SAM_node[u].mat[i]);
106     ans=max(ans,tmp);
107 }
108 int main()
109 {
110
111     while (scanf("%s",s[n])!=EOF)
112         n++;
113     int L=strlen(s[0]);
114     ans=M=0;
115     SAM_build(s[0]);
116     for (int j=1; j<n; j++)
117     {
118         int l=strlen(s[j]),len=0;
119         SAM_Node *p=SAM_root;
120         for (int i=0; i<l; i++)
121         {
122             if (p->next[getid(s[j][i])])
123             {
124                 p=p->next[getid(s[j][i])];
125                 p->mat[j-1]=max(p->mat[j-1],++len);
126             }
127             else
128             {
129                 while (p && !p->next[getid(s[j][i])])
130                     p=p->fa;
131                 if (!p)
132                 {
133                     p=SAM_root;
134                     len=0;
135                 }
136                 else
137                 {
138                     len=p->len+1;
139                     p=p->next[getid(s[j][i])];
140                 }
141                 p->mat[j-1]=max(p->mat[j-1],len);
142             }
143         }
144     }

```

```

145     memset(head,-1,4*SAM_size);
146     for (int i=1; i<SAM_size; i++)
147         add_edge(SAM_node[i].fa->id,i);
148     dfs(0);
149     printf("%d\n",ans);
150     return 0;
151 }

```

## LCS2

```

1  #include <iostream>
2  #include <algorithm>
3  #include <cstdio>
4  #include <cstring>
5  using namespace std;
6
7  const int CHAR = 26;
8  const int MAXN = 100000;
9
10 struct SAM_Node
11 {
12     SAM_Node *fa,*next[CHAR];
13     int len;
14     int id;
15     int mat[9];
16     SAM_Node() {}
17     SAM_Node(int _len)
18     {
19         fa = 0;
20         len = _len;
21         memset(mat,0,sizeof(mat));
22         memset(next,0,sizeof(next));
23     }
24 };
25 SAM_Node SAM_node[MAXN*2],*SAM_root,*SAM_last;
26 int SAM_size;
27 SAM_Node *newSAM_Node(int len)
28 {
29     SAM_node[SAM_size] = SAM_Node(len);
30     SAM_node[SAM_size].id = SAM_size;
31     return &SAM_node[SAM_size++];
32 }
33 SAM_Node *newSAM_Node(SAM_Node *p)
34 {
35     SAM_node[SAM_size] = *p;
36     SAM_node[SAM_size].id = SAM_size;
37     return &SAM_node[SAM_size++];
38 }
39 void SAM_init()
40 {
41     SAM_size = 0;
42     SAM_root = SAM_last = newSAM_Node(0);
43 }
44 void SAM_add(int x,int len)
45 {
46     SAM_Node *p = SAM_last,*np = newSAM_Node(p->len+1);
47     SAM_last = np;
48     for (; p&&!p->next[x]; p=p->fa)
49         p->next[x] = np;
50     if (!p)
51     {
52         np->fa = SAM_root;
53         return;

```

```

54     }
55     SAM_Node *q = p->next[x];
56     if (q->len == p->len+1)
57     {
58         np->fa = q;
59         return;
60     }
61     SAM_Node *nq = newSAM_Node(q);
62     nq->len = p->len+1;
63     q->fa = nq;
64     np->fa = nq;
65     for (; p&& p->next[x] == q; p = p->fa)
66         p->next[x] = nq;
67 }
68 int getid(char ch)
69 {
70     return ch-'a';
71 }
72 void SAM_build(char *s)
73 {
74     SAM_init();
75     int l = strlen(s);
76     for (int i = 0; i < l; i++)
77         SAM_add(getid(s[i]),i+1);
78 }
79 char s[MAXN+1];
80 int ans;
81 int head[MAXN*2];
82 struct Edge
83 {
84     int to,next;
85 } edge[MAXN*2];
86 int M;
87 int n;
88 void add_edge(int u,int v)
89 {
90     edge[M].to=v;
91     edge[M].next=head[u];
92     head[u]=M++;
93 }
94 void dfs(int u)
95 {
96     for (int i=head[u]; i!=-1; i=edge[i].next)
97     {
98         int v=edge[i].to;
99         /*for (int j=0; j<n; j++)
100             SAM_node[v].mat[j]=max(SAM_node[v].mat[j],SAM_node[u].mat[j]);*/
101         dfs(v);
102         for (int j=0; j<n; j++)
103             SAM_node[u].mat[j]=max(SAM_node[v].mat[j],SAM_node[u].mat[j]);
104     }
105     int tmp=SAM_node[u].len;
106     for (int i=0; i<n; i++)
107         tmp=min(tmp,SAM_node[u].mat[i]);
108     ans=max(ans,tmp);
109 }
110 int main()
111 {
112     //freopen("in.txt","r",stdin);
113     //freopen("out.txt","w",stdout);
114     n=0;
115     gets(s);
116     SAM_build(s);

```



```

117     while (gets(s))
118     {
119         int l=strlen(s),len=0;
120         SAM_Node *p=SAM_root;
121         for (int i=0; i<l; i++)
122         {
123             if (p->next[getid(s[i])])
124             {
125                 p=p->next[getid(s[i])];
126                 p->mat[n]=max(p->mat[n],++len);
127             }
128             else
129             {
130                 while (p && !p->next[getid(s[i])])
131                     p=p->fa;
132                 if (!p)
133                 {
134                     p=SAM_root;
135                     len=0;
136                 }
137                 else
138                 {
139                     len=p->len+1;
140                     p=p->next[getid(s[i])];
141                 }
142                 p->mat[n]=max(p->mat[n],len);
143             }
144             //printf("%d %d %d\n",i,len,p->id);
145         }
146         n++;
147     }
148     memset(head,-1,4*SAM_size);
149     for (int i=1; i<SAM_size; i++)
150         add_edge(SAM_node[i].fa->id,i);
151     dfs(0);
152     printf("%d\n",ans);
153     return 0;
154 }

```

### 3.4 KMP

求A[0..i]的一个后缀最多能匹配B的前缀多长。先对B进行自匹配然后与A匹配。KMP[i]就是对应答案，p[i]+1是B[0..i]的一个后缀最多能匹配B的前缀多长。

```

1 //自匹配过程
2 int j;
3 p[0] = j = -1;
4 for (int i = 1; i < lb; i++)
5 {
6     while (j >= 0 && b[j + 1] != b[i]) j = p[j];
7     if (b[j + 1] == b[i]) j ++;
8     p[i] = j;
9 }
10 //下面是匹配过程
11 j = -1;
12 for (int i = 0; i < la; i++)
13 {
14     while (j >= 0 && b[j + 1] != a[i]) j = p[j];
15     if (b[j + 1] == a[i]) j ++;
16     KMP[i] = j + 1;
17 }

```

### 3.5 e-KMP

求A[i..len-1]和B的最长公共前缀有多长。先对B进行自匹配然后与A匹配。eKMP[i]就是对应答案。p[i]是B[i..len-1]和B的最长公共前缀有多长。

```
1 //自匹配过程
2 int j = 0;
3 while (j < lb && b[j] == b[j + 1])
4     j++;
5 p[0] = lb, p[1] = j;
6 int k = 1;
7 for (int i = 2; i < lb; i++)
8 {
9     int Len = k + p[k] - 1, L = p[i - k];
10    if (L < Len - i + 1)
11        p[i] = L;
12    else
13    {
14        j = max(0, Len - i + 1);
15        while (i + j < lb && b[i + j] == b[j])
16            j++;
17        p[i] = j, k = i;
18    }
19 }
20 //下面是匹配过程
21 j = 0;
22 while (j < la && j < lb && a[j] == b[j])
23     j++;
24 eKMP[0] = j;
25 k = 0;
26 for (int i = 1; i < la; i++)
27 {
28     int Len = k + eKMP[k] - 1, L = p[i - k];
29     if (L < Len - i + 1)
30         eKMP[i] = L;
31     else
32     {
33         j = max(0, Len - i + 1);
34         while (i + j < la && j < lb && a[i + j] == b[j])
35             j++;
36         eKMP[i] = j, k = i;
37     }
38 }
```

### 3.6 \*Manacher

待整理

```
1 char s[1000], a[3000];
2 int p[3000], len, l, pnow, pid, res, resid;
3
4 int main()
5 {
6     while (scanf("%s", s) != EOF)
7     {
8         len = strlen(s);
9         l = 0;
10        a[l++] = '.';
11        a[l++] = ',';
12        for (int i = 0; i < len; i++)
13        {
14            a[l++] = s[i];
15            a[l++] = ',';
16        }
17    }
```

```

17     pnow = 0;
18     res = 0;
19     for (int i = 1; i < l; i++)
20     {
21         if (pnow > i)
22             p[i] = min(p[2*pid-i], pnow-i);
23         else
24             p[i] = 1;
25         for (; a[i-p[i]] == a[i+p[i]]; p[i]++);
26         if (i+p[i] > pnow)
27         {
28             pnow = i+p[i];
29             pid = i;
30         }
31         if (p[i] > res)
32         {
33             res = p[i];
34             resid = i;
35         }
36     }
37     for (int i = resid-res+2; i < resid+res-1; i += 2)
38         printf("%c", a[i]);
39     printf("\n");
40 }
41 return 0;
42 }

```

### 3.7 \*字符串最小表示法

```

1 int Gao(char a[], int len)
2 {
3     int i = 0, j = 1, k = 0;
4     while (i < len && j < len && k < len)
5     {
6         int cmp = a[(j+k)%len] - a[(i+k)%len];
7         if (cmp == 0)
8             k++;
9         else
10        {
11            if (cmp > 0)
12                j += k+1;
13            else
14                i += k+1;
15            if (i == j) j++;
16            k = 0;
17        }
18    }
19    return min(i, j);
20 }

```

## 4 数学

### 4.1 模线性方程组

```
1 //有更新
2 int m[10],a[10]; //模数m 余数a
3 bool solve(int &m0,int &a0,int m,int a) //模线性方程组
4 {
5     int y,x;
6     int g=ex_gcd(m0,m,x,y);
7     if (abs(a-a0)%g) return 0;
8     x*=(a-a0)/g;
9     x%=m/g;
10    a0=(x*m0+a0);
11    m0*=m/g;
12    a0%=m0;
13    if (a0<0) a0+=m0;
14    return 1;
15 }
16 int MLES()
17 {
18     bool flag=1;
19     int m0=1,a0=0;
20     for (int i=0; i<n; i++)
21         if (!solve(m0,a0,m[i],a[i]))
22             {
23                 flag=0;
24                 break;
25             }
26     if (flag)
27         return a0;
28     else
29         return -1;
30 }
```

### 4.2 扩展GCD

求 $ax+by=\gcd(a,b)$ 的一组解

```
1 long long ex_gcd(long long a,long long b,long long &x,long long &y)
2 {
3     if (b)
4     {
5         long long ret = ex_gcd(b,a%b,x,y),tmp = x;
6         x = y;
7         y = tmp-(a/b)*y;
8         return ret;
9     }
10    else
11    {
12        x = 1;
13        y = 0;
14        return a;
15    }
16 }
```

### 4.3 矩阵

乘法的时候将 $B$ 数组转置一下然后 $C[i][j] = \sum A[i][k] \times B[j][k]$ 会有奇效。

```
1 struct Matrix
2 {
3     int a[52][52];
4     Matrix operator * (const Matrix &b) const
```

```

5      {
6          Matrix res;
7          for (int i = 0; i < 52; i++)
8              for (int j = 0; j < 52; j++)
9                  {
10                     res.a[i][j] = 0;
11                     for (int k = 0; k < 52; k++)
12                         res.a[i][j] += a[i][k] * b.a[k][j];
13                 }
14          return res;
15      }
16      Matrix operator ^ (int y) const
17      {
18          Matrix res, x;
19          for (int i = 0; i < 52; i++)
20              {
21                  for (int j = 0; j < 52; j++)
22                      res.a[i][j] = 0, x.a[i][j] = a[i][j];
23                  res.a[i][i] = 1;
24              }
25          for (; y; y >>= 1, x = x * x)
26              if (y & 1)
27                  res = res * x;
28          return res;
29      }
30 };

```

#### 4.4 康拓展开

```

1  const int PermSize = 12;
2  int factory[PermSize] = {1, 1, 2, 6, 24, 120, 720, 5040, 40320, 362880,
3  3628800, 39916800};
4  int Cantor(int a[])
5  {
6      int i, j, counted;
7      int result = 0;
8      for (i = 0; i < PermSize; ++i)
9          {
10             counted = 0;
11             for (j = i + 1; j < PermSize; ++j)
12                 if (a[i] > a[j])
13                     ++counted;
14             result = result + counted * factory[PermSize - i - 1];
15         }
16     return result;
17 }
18 bool h[13];
19
20 void UnCantor(int x, int res[])
21 {
22     int i, j, l, t;
23     for (i = 1; i <= 12; i++)
24         h[i] = false;
25     for (i = 1; i <= 12; i++)
26     {
27         t = x / factory[12 - i];
28         x -= t * factory[12 - i];
29         for (j = 1, l = 0; l <= t; j++)
30             if (!h[j]) l++;
31         j--;
32         h[j] = true;

```

```

33         res[i - 1] = j;
34     }
35 }

```

## 4.5 FFT

```

1  const double PI= acos(-1.0);
2  struct vir
3  {
4      double re,im; //实部和虚部
5      vir(double a=0,double b=0)
6      {
7          re=a;
8          im=b;
9      }
10     vir operator +(const vir &b)
11     {return vir(re+b.re,im+b.im);}
12     vir operator -(const vir &b)
13     {return vir(re-b.re, im-b.im);}
14     vir operator *(const vir &b)
15     {return vir(re*b.re-im*b.im , re*b.im+im*b.re);}
16 };
17 vir x1[200005],x2[200005];
18 void change(vir *x,int len,int loglen)
19 {
20     int i,j,k,t;
21     for(i=0;i<len;i++)
22     {
23         t=i;
24         for(j=k=0; j<loglen; j++,t>=1)
25             k= (k<<1)|(t&1);
26         if(k<i)
27         {
28             // printf("%d %d\n",k,i);
29             vir wt=x[k];
30             x[k]=x[i];
31             x[i]=wt;
32         }
33     }
34 }
35 void fft(vir *x,int len,int loglen)
36 {
37     int i,j,t,s,e;
38     change(x,len,loglen);
39     t=1;
40     for(i=0;i<loglen;i++,t<=1)
41     {
42         s=0;
43         e=s+t;
44         while(s<len)
45         {
46             vir a,b,wo(cos(PI/t),sin(PI/t)),wn(1,0);
47             for(j=s;j<s+t;j++)
48             {
49                 a=x[j];
50                 b=x[j+t]*wn;
51                 x[j]=a+b;
52                 x[j+t]=a-b;
53                 wn=wn*wo;
54             }
55             s=e+t;
56             e=s+t;
57         }
58     }

```

```

59 }
60 void dit_fft(vir *x,int len,int loglen)
61 {
62     int i,j,s,e,t=1<<loglen;
63     for(i=0;i<loglen;i++)
64     {
65         t>>=1;
66         s=0;
67         e=s+t;
68         while(s<len)
69         {
70             vir a,b,wn(1,0),wo(cos(PI/t),-sin(PI/t));
71             for(j=s;j<s+t;j++)
72             {
73                 a=x[j]+x[j+t];
74                 b=(x[j]-x[j+t])*wn;
75                 x[j]=a;
76                 x[j+t]=b;
77                 wn=wn*wo;
78             }
79             s=e+t;
80             e=s+t;
81         }
82     }
83     change(x,len,loglen);
84     for(i=0;i<len;i++)
85         x[i].re/=len;
86 }
87 int main()
88 {
89     char a[100005],b[100005];
90     int i,len1,len2,len,loglen;
91     int t,over;
92     while(scanf("%s%s",a,b)!=EOF)
93     {
94         len1=strlen(a)<<1;
95         len2=strlen(b)<<1;
96         len=1;loglen=0;
97         while(len<len1)
98         {
99             len<=<=1;    loglen++;
100         }
101         while(len<len2)
102         {
103             len<=<=1;    loglen++;
104         }
105         for(i=0;a[i];i++)
106         {
107             x1[i].re=a[i]-'0';
108             x1[i].im=0;
109         }
110         for(;i<len;i++)
111             x1[i].re=x1[i].im=0;
112         for(i=0;b[i];i++)
113         {
114             x2[i].re=b[i]-'0';
115             x2[i].im=0;
116         }
117         for(;i<len;i++)
118             x2[i].re=x2[i].im=0;
119         fft(x1,len,loglen);
120         fft(x2,len,loglen);
121         for(i=0;i<len;i++)

```

```

122     x1[i] = x1[i]*x2[i];
123     dit_fft(x1,len,loglen);
124     for(i=(len1+len2)/2-2,over=len=0;i>=0;i--)
125     {
126         t=(int)(x1[i].re+over+0.5);
127         a[len++]= t%10;
128         over = t/10;
129     }
130     while(over)
131     {
132         a[len++]=over%10;
133         over/=10;
134     }
135     for(len--;len>=0&&!a[len];len--);
136     if(len<0)
137         putchar('0');
138     else
139         for(;len>=0;len--)
140             putchar(a[len]+'0');
141     putchar('\n');
142 }
143 return 0;
144 }

```

#### 4.6 爬山法计算器

注意灵活运用。

双目运算符在calc()中，左结合单目运算符在P()中，右结合单目运算符在calc\_exp中。（但是还没遇到过。。）

```

1  #include <iostream>
2  #include <cstdio>
3  #include <cstring>
4  #include <algorithm>
5  #include <string>
6  using namespace std;
7
8  char s[100000];
9  int n,cur;
10 const string OP = "+-*/";
11
12 char next_char()
13 {
14     if (cur >= n) return EOF;
15     return s[cur];
16 }
17
18 int get_priority(char ch)
19 {
20     if (ch == '*') return 2;
21     return 1;
22 }
23
24 int P();
25
26 int calc(int a,char op,int b)
27 {
28     if (op == '+')
29         return a+b;
30     if (op == '-')
31         return a-b;
32     if (op == '*')
33         return a*b;
34 }

```



```

35
36 int calc_exp(int p)
37 {
38     int a = P();
39     while ((OP.find(next_char()) != OP.npos) && (get_priority(next_char())
40         >= p))
41     {
42         char op = next_char();
43         cur++;
44         a = calc(a,op,calc_exp(get_priority(op)+1));
45     }
46     return a;
47 }
48
49 int totvar,m,var[26],varid[26];
50
51 int P()
52 {
53     if (next_char() == '-')
54     {
55         cur++;
56         return -P();
57     }
58     else if (next_char() == '+')
59     {
60         cur++;
61         return P();
62     }
63     else if (next_char() == '(')
64     {
65         cur++;
66         int res = calc_exp(0);
67         cur++;
68         return res;
69     }
70     else
71     {
72         cur++;
73         //cout << "getvar at " << cur << ' ' << var[varid[s[cur]-'a']] <<
74             endl;
75         return var[varid[s[cur-1]-'a']];
76     }
77 }
78
79 int id[26],minid;
80
81 int main()
82 {
83     while (true)
84     {
85         scanf("%d",&totvar,&var[0]);
86         if (totvar == 0 && var[0] == 0) break;
87         for (int i = 1;i < totvar;i++)
88             scanf("%d",&var[i]);
89         scanf("%d",&m);
90         scanf("%s",s);
91         for (int i = 0;i < 26;i++)
92             id[i] = -1;
93         minid = 0;
94         n = strlen(s);
95         for (int i = 0;i < n;i++)
96             if (s[i] >= 'a' && s[i] <= 'z')
97                 {

```

```

96         if (id[s[i]-'a'] == -1)
97         {
98             id[s[i]-'a'] = minid;
99             minid++;
100        }
101        s[i] = 'a'+id[s[i]-'a'];
102    }
103    for (int i = 0; i < totvar; i++)
104        varid[i] = i;
105    int res = 0;
106    do
107    {
108        cur = 0;
109        int tmp = calc_exp(0);
110        if (tmp == m)
111        {
112            res++;
113            break;
114        }
115    }
116    while (next_permutation(varid, varid+totvar));
117    //puts(s);
118    if (res > 0)
119        puts("YES");
120    else
121        puts("NO");
122    }
123    return 0;
124 }

```

## 4.7 线性筛

我弱逼。

```

1 void getprime()
2 {
3     tot = 0;
4     memset(isprime, true, sizeof(isprime));
5     for (int i = 2; i <= 40000000; i++)
6     {
7         if (isprime[i] == true)
8         {
9             tot++;
10            prime[tot] = i;
11        }
12        for (int j = 1; j <= tot && i*prime[j] <= 40000000; j++)
13        {
14            isprime[i*prime[j]] = false;
15            if (i%prime[j] == 0) break;
16        }
17    }
18 }

```

## 4.8 其它公式

### 4.8.1 正多面体顶点着色

正四面体:  $N = \frac{(n^4+11n^2)}{24}$

正六面体:  $N = \frac{(n^8+17n^4+6n^2)}{24}$

正八面体:  $N = \frac{(n^6+3n^4+12n^3+8n^2)}{24}$

正十二面体:  $N = \frac{(n^{20}+15n^{10}+20n^8+24n^4)}{60}$

正二十面体:  $N = \frac{(n^{12} + 15 \times n^6 + 44 \times n^4)}{60}$

#### 4.8.2 求和公式

$$\begin{aligned}\sum k &= \frac{n \times (n+1)}{2} \\ \sum 2k - 1 &= n^2 \\ \sum k^2 &= \frac{n \times (n+1) \times (2n+1)}{6} \\ \sum (2k-1)^2 &= \frac{n \times (4n^2-1)}{3} \\ \sum k^3 &= \left(\frac{n \times (n+1)}{2}\right)^2 \\ \sum (2k-1)^3 &= n^2 \times (2n^2-1) \\ \sum k^4 &= \frac{n \times (n+1) \times (2n+1) \times (3n^2+3n-1)}{30} \\ \sum k^5 &= \frac{n^2 \times (n+1)^2 \times (2n^2+2n-1)}{12} \\ \sum k \times (k+1) &= \frac{n \times (n+1) \times (n+2)}{3} \\ \sum k \times (k+1) \times (k+2) &= \frac{n \times (n+1) \times (n+2) \times (n+3)}{4} \\ \sum k \times (k+1) \times (k+2) \times (k+3) &= \frac{n \times (n+1) \times (n+2) \times (n+3) \times (n+4)}{5}\end{aligned}$$

#### 4.8.3 几何公式

球扇形:

全面积:  $T = \pi r(2h + r_0)$ ,  $h$  为球冠高,  $r_0$  为球冠底面半径

体积:  $V = \frac{2\pi r^2 h}{3}$

#### 4.8.4 小公式

Pick 公式:  $A = E \times 0.5 + I - 1$  ( $A$  是多边形面积,  $E$  是边界上的整点,  $I$  是多边形内部的整点)

海伦公式:  $S = \sqrt{p(p-a)(p-b)(p-c)}$ , 其中  $p = \frac{(a+b+c)}{2}$ ,  $abc$  为三角形的三条边长

求  $\binom{n}{k}$  中素因子  $P$  的个数:

1. 把  $n$  转化为  $P$  进制, 并记它每个位上的和为  $S1$
2. 把  $n-k$ ,  $k$  做同样的处理, 得到  $S2$ ,  $S3$

则  $\binom{n}{k}$  中素因子  $P$  的个数:  $\frac{S2+S3-S1}{P-1}$

枚举长为  $n$  含  $k$  个 1 的 01 串:

```
1 | for (int s = (1 << k)-1, u = 1 << n; s < u;)
2 | {
3 |     ...;
4 |     int b = s & -s;
5 |     s = (s+b) | (((s^(s+b))>>2)/b);
6 | }
```

## 5 数据结构

### 5.1 \*Splay

持续学习中。

注意节点的size值不一定是真实的值！如果有需要需要特别维护！

1. 旋转和Splay操作
2. rank操作
3. insert操作（。。很多题目都有）
4. del操作（郁闷的出纳员）
5. 由数组建立Splay
6. 前驱后继（营业额统计）
7. Pushdown Pushup的位置
8. \*。。。暂时想不起了

节点定义。。

```
1 | const int MaxN = 50003;
2 |
3 | struct Node
4 | {
5 |     int size, key;
6 |
7 |     Node *c[2];
8 |     Node *p;
9 | } mem[MaxN], *cur, *nil;
```

无内存池的几个初始化函数。

```
1 | Node *newNode(int v, Node *p)
2 | {
3 |     cur->c[0] = cur->c[1] = nil, cur->p = p;
4 |     cur->size = 1;
5 |     cur->key = v;
6 |     return cur++;
7 | }
8 |
9 | void Init()
10 | {
11 |     cur = mem;
12 |     nil = newNode(0, cur);
13 |     nil->size = 0;
14 | }
```

带内存池的几个函数。

```
1 | int emp[MaxN], totemp;
2 |
3 | Node *newNode(int v, Node *p)
4 | {
5 |     cur = mem + emp[--totemp];
6 |     cur->c[0] = cur->c[1] = nil, cur->p = p;
7 |     cur->size = 1;
8 |     cur->key = v;
9 |     return cur;
10 | }
11 |
```

```

12 void Init()
13 {
14     for (int i = 0; i < MaxN; ++i)
15         emp[i] = i;
16     totemp = MaxN;
17     cur = mem + emp[--totemp];
18     nil = newNode(0, cur);
19     nil->size = 0;
20 }
21
22 void Recycle(Node *p)
23 {
24     if (p == nil) return;
25     Recycle(p->c[0]), Recycle(p->c[1]);
26     emp[totemp++] = p - mem;
27 }

```

基本的Splay框架。维护序列用。  
一切下标从0开始。

```

1 struct SplayTree
2 {
3     Node *root;
4     void Init()
5     {
6         root = nil;
7     }
8     void Pushup(Node *x)
9     {
10         if (x == nil) return;
11         Pushdown(x); Pushdown(x->c[0]); Pushdown(x->c[1]);
12         x->size = x->c[0]->size + x->c[1]->size + 1;
13     }
14     void Pushdown(Node *x)
15     {
16         if (x == nil) return;
17         //do something
18     }
19     void Rotate(Node *x, int f)
20     {
21         if (x == nil) return;
22         Node *y = x->p;
23         y->c[f ^ 1] = x->c[f], x->p = y->p;
24         if (x->c[f] != nil)
25             x->c[f]->p = y;
26         if (y->p != nil)
27             y->p->c[y->p->c[1] == y] = x;
28         x->c[f] = y, y->p = x;
29         Pushup(y);
30     }
31     void Splay(Node *x, Node *f)
32     {
33         while (x->p != f)
34         {
35             Node *y = x->p;
36             if (y->p == f)
37                 Rotate(x, x == y->c[0]);
38             else
39             {
40                 int fd = y->p->c[0] == y;
41                 if (y->c[fd] == x)
42                     Rotate(x, fd ^ 1), Rotate(x, fd);
43                 else

```

```

44         Rotate(y, fd), Rotate(x, fd);
45     }
46 }
47 Pushup(x);
48 if (f == nil)
49     root = x;
50 }
51 void Select(int k, Node *f)
52 {
53     Node *x = root;
54     Pushdown(x);
55     int tmp;
56     while ((tmp = x->c[0]->size) != k)
57     {
58         if (k < tmp)    x = x->c[0];
59         else
60             x = x->c[1], k -= tmp + 1;
61         Pushdown(x);
62     }
63     Splay(x, f);
64 }
65 void Select(int l, int r)
66 {
67     Select(l, nil), Select(r + 2, root);
68 }
69 Node *Make_tree(int a[], int l, int r, Node *p)
70 {
71     if (l > r)    return nil;
72     int mid = l + r >> 1;
73     Node *x = newNode(a[mid], p);
74     x->c[0] = Make_tree(a, l, mid - 1, x);
75     x->c[1] = Make_tree(a, mid + 1, r, x);
76     Pushup(x);
77     return x;
78 }
79 void Insert(int pos, int a[], int n)
80 {
81     Select(pos, nil), Select(pos + 1, root);
82     root->c[1]->c[0] = Make_tree(a, 0, n - 1, root->c[1]);
83     Splay(root->c[1]->c[0], nil);
84 }
85 void Insert(int v)
86 {
87     Node *x = root, *y = nil;
88     while (x != nil)
89     {
90         y = x;
91         y->size++;
92         x = x->c[v >= x->key];
93     }
94     y->c[v >= y->key] = x = newNode(v, y);
95     Splay(x, nil);
96 }
97 void Remove(int l, int r)
98 {
99     Select(l, r);
100     //Recycle(root->c[1]->c[0]);
101     root->c[1]->c[0] = nil;
102     Splay(root->c[1], nil);
103 }
104 };

```

例题：旋转区间赋值求和求最大子序列。

注意打上懒标记后立即Pushup。Pushup(root->c[1]->c[0]),Pushup(root->c[1]),Pushup(root);

```

1 void Pushup(Node *x)
2 {
3     if (x == nil) return;
4     Pushdown(x); Pushdown(x->c[0]); Pushdown(x->c[1]);
5     x->size = x->c[0]->size+x->c[1]->size+1;
6
7     x->sum = x->c[0]->sum+x->c[1]->sum+x->key;
8     x->lsum = max(x->c[0]->lsum, x->c[0]->sum+x->key+max(0, x->c[1]->lsum));
9     x->rsum = max(x->c[1]->rsum, x->c[1]->sum+x->key+max(0, x->c[0]->rsum));
10    x->maxsum = max(max(x->c[0]->maxsum, x->c[1]->maxsum), x->key+max(0, x->c[0]->rsum)+max(0, x->c[1]->lsum));
11 }
12 void Pushdown(Node *x)
13 {
14     if (x == nil) return;
15     if (x->rev)
16     {
17         x->rev = 0;
18         x->c[0]->rev ^= 1;
19         x->c[1]->rev ^= 1;
20         swap(x->c[0], x->c[1]);
21
22         swap(x->lsum, x->rsum);
23     }
24     if (x->same)
25     {
26         x->same = false;
27         x->key = x->lazy;
28         x->sum = x->key*x->size;
29         x->lsum = x->rsum = x->maxsum = max(x->key, x->sum);
30         x->c[0]->same = true, x->c[0]->lazy = x->key;
31         x->c[1]->same = true, x->c[1]->lazy = x->key;
32     }
33 }
34
35 int main()
36 {
37     int totcas;
38     scanf("%d", &totcas);
39     for (int cas = 1; cas <= totcas; cas++)
40     {
41         Init();
42         sp.Init();
43         nil->lsum = nil->rsum = nil->maxsum = -Inf;
44         sp.Insert(0);
45         sp.Insert(0);
46
47         int n, m;
48         scanf("%d%d", &n, &m);
49         for (int i = 0; i < n; i++)
50             scanf("%d", &a[i]);
51         sp.Insert(0, a, n);
52
53         for (int i = 0; i < m; i++)
54         {
55             int pos, tot, c;
56             scanf("%s", buf);
57             if (strcmp(buf, "MAKE-SAME") == 0)
58             {
59                 scanf("%d%d%d", &pos, &tot, &c);
60                 sp.Select(pos-1, pos+tot-2);
61                 sp.root->c[1]->c[0]->same = true;

```

```

62         sp.root->c[1]->c[0]->lazy = c;
63         sp.Pushup(sp.root->c[1]), sp.Pushup(sp.root);
64     }
65     else if (strcmp(buf,"INSERT") == 0)
66     {
67         scanf("%d%d",&pos,&tot);
68         for (int i = 0;i < tot;i++)
69             scanf("%d",&a[i]);
70         sp.Insert(pos,a,tot);
71     }
72     else if (strcmp(buf,"DELETE") == 0)
73     {
74         scanf("%d%d",&pos,&tot);
75         sp.Remove(pos-1,pos+tot-2);
76     }
77     else if (strcmp(buf,"REVERSE") == 0)
78     {
79         scanf("%d%d",&pos,&tot);
80         sp.Select(pos-1,pos+tot-2);
81         sp.root->c[1]->c[0]->rev ^= 1;
82         sp.Pushup(sp.root->c[1]), sp.Pushup(sp.root);
83     }
84     else if (strcmp(buf,"GET-SUM") == 0)
85     {
86         scanf("%d%d",&pos,&tot);
87         sp.Select(pos-1,pos+tot-2);
88         printf("%d\n",sp.root->c[1]->c[0]->sum);
89     }
90     else if (strcmp(buf,"MAX-SUM") == 0)
91     {
92         sp.Select(0,sp.root->size-3);
93         printf("%d\n",sp.root->c[1]->c[0]->maxsum);
94     }
95 }
96 }
97 return 0;
98 }

```

维护多个序列的时候，不需要建立很多Splay。只需要记录某个点在内存池中的绝对位置就可以了。需要操作它所在的序列时直接Splay到nil。此时Splay的root所在的Splay就是这个序列了。新建序列的时候需要多加入两个额外节点。如果某个Splay只有两个节点了需要及时回收。  
 例题：Box（维护括号序列）

```

1  \\\下面都是专用函数
2  \\\判断x在不在f里面
3  bool Ancestor(Node *x,Node *f)
4  {
5      if (x == f) return true;
6      while (x->p != nil)
7      {
8          if (x->p == f) return true;
9          x = x->p;
10     }
11     return false;
12 }
13 \\\把Splay v插入到pos后面, pos=nil时新开一个序列
14 void Insert(Node *pos, Node *v)
15 {
16     int pl;
17     if (pos == nil)
18     {
19         Init();
20         Insert(0), Insert(0);

```



```

21         pl = 0;
22     }
23     else
24     {
25         Splay(pos, nil);
26         pl = root->c[0]->size;
27     }
28     Select(pl, nil), Select(pl + 1, root);
29     root->c[1]->c[0] = v;
30     v->p = root->c[1];
31     Splay(v, nil);
32 }
33 \\把[l,r]转出来 (这里记录的是绝对位置)
34 void Select(Node *l, Node *r)
35 {
36     Splay(l, nil);
37     int pl = root->c[0]->size - 1;
38     Splay(r, nil);
39     int pr = root->c[0]->size - 1;
40     Select(pl, pr);
41 }
42 \\分离[l,r]
43 Node *Split(Node *l, Node *r)
44 {
45     Select(l, r);
46     Node *res = root->c[1]->c[0];
47     root->c[1]->c[0] = res->p = nil;
48     Splay(root->c[1], nil);
49     if (root->size == 2)
50     {
51         Recycle(root);
52         Init();
53     }
54     return res;
55 }
56
57 int main(int argc, char const *argv[])
58 {
59     freopen("P.in", "r", stdin);
60     bool first = true;
61     while (scanf("%d", &n) != EOF)
62     {
63         if (!first) puts("");
64         first = false;
65         Init();
66         for (int i = 0; i < n; i++)
67         {
68             \\建立独立的N个区间, 记录绝对位置
69             sp.Init();
70             sp.Insert(0), sp.Insert(0);
71             sp.Insert(0, i+1), sp.Insert(1, i+1);
72             sp.Select(0, 0), l[i] = sp.root->c[1]->c[0];
73             sp.Select(1, 1), r[i] = sp.root->c[1]->c[0];
74         }
75         for (int i = 0; i < n; i++)
76         {
77             int f;
78             scanf("%d", &f);
79             if (f != 0)
80             {
81                 \\把[l[i],r[i]]插入到l[f-1]后面
82                 Node *pos = sp.Split(l[i], r[i]);
83                 sp.Insert(l[f - 1], pos);

```

```

84         }
85     }
86     scanf("%d", &n);
87     for (int i = 0; i < n; i++)
88     {
89         scanf("%s", com);
90         if (com[0] == 'Q')
91         {
92             int pos;
93             scanf("%d", &pos);
94             \\求[l[pos-1],r[pos-1]]在哪个序列里面
95             sp.Splay(l[pos - 1], nil);
96             sp.Select(1, nil);
97             printf("%d\n", sp.root->key);
98         }
99         else
100        {
101            int u, v;
102            scanf("%d%d", &u, &v);
103            if (v == 0)
104                sp.Insert(nil, sp.Split(l[u-1], r[u-1]));
105            else
106            {
107                sp.Select(l[u-1], r[u-1]);
108                if (sp.Ancestor(l[v-1], sp.root->c[1]->c[0]) == false)
109                    sp.Insert(l[v - 1], sp.Split(l[u-1], r[u-1]));
110            }
111        }
112    }
113 }
114 return 0;
115 }

```

## 5.2 \*动态树

### 5.2.1 维护点权

被注释的部分是具体题目用到的东西。

支持换根。

Cut操作还没写。

```

1  const int MaxN = 110000;
2
3  struct Node
4  {
5      int size, key;
6      bool rev;
7
8      //    bool same;
9      //    int lsum, rsum, sum, maxsum, sa;
10
11      Node *c[2];
12      Node *p;
13 } mem[MaxN], *cur, *nil, *pos[MaxN];
14
15 Node *newNode(int v, Node *p)
16 {
17     cur->c[0] = cur->c[1] = nil, cur->p = p;
18     cur->size = 1;
19     cur->key = v;
20     cur->rev = false;
21
22     //    cur->same = false;

```

```

23 // cur->sa = 0;
24 // cur->lsum = cur->rsum = cur->maxsum = 0;
25 // cur->sum = v;
26
27     return cur++;
28 }
29
30 void Init()
31 {
32     cur = mem;
33     nil = newNode(0, cur);
34     nil->size = 0;
35 }
36
37 struct SplayTree
38 {
39     void Pushup(Node *x)
40     {
41         if (x == nil) return;
42         Pushdown(x); Pushdown(x->c[0]); Pushdown(x->c[1]);
43         x->size = x->c[0]->size + x->c[1]->size + 1;
44
45         x->sum = x->c[0]->sum + x->c[1]->sum + x->key;
46         x->lsum = max(x->c[0]->lsum, x->c[0]->sum + x->key + max(0, x->c
47         [1]->lsum));
48         x->rsum = max(x->c[1]->rsum, x->c[1]->sum + x->key + max(0, x->c
49         [0]->rsum));
50         x->maxsum = max(max(x->c[0]->maxsum, x->c[1]->maxsum),
51         x->key + max(0, x->c[0]->rsum) + max(0, x->c[1]->lsum));
52     }
53     void Pushdown(Node *x)
54     {
55         if (x == nil) return;
56         if (x->rev)
57         {
58             x->rev = 0;
59             x->c[0]->rev ^= 1;
60             x->c[1]->rev ^= 1;
61             swap(x->c[0], x->c[1]);
62         }
63         //注意修改与位置有关的量
64         swap(x->lsum, x->rsum);
65     }
66     if (x->same)
67     {
68         x->same = false;
69         x->key = x->sa;
70         x->sum = x->sa * x->size;
71         x->lsum = x->rsum = x->maxsum = max(0, x->sum);
72         if (x->c[0] != nil)
73             x->c[0]->same = true, x->c[0]->sa = x->sa;
74         if (x->c[1] != nil)
75             x->c[1]->same = true, x->c[1]->sa = x->sa;
76     }
77 }
78 bool isRoot(Node *x)
79 {
80     return (x == nil) || (x->p->c[0] != x && x->p->c[1] != x);
81 }
82 void Rotate(Node *x, int f)
83 {
84     if (isRoot(x)) return;

```

```

84     Node *y = x->p;
85     y->c[f ^ 1] = x->c[f], x->p = y->p;
86     if (x->c[f] != nil)
87         x->c[f]->p = y;
88     if (y != nil)
89     {
90         if (y == y->p->c[1])
91             y->p->c[1] = x;
92         else if (y == y->p->c[0])
93             y->p->c[0] = x;
94     }
95     x->c[f] = y, y->p = x;
96     Pushup(y);
97 }
98 void Splay(Node *x)
99 {
100     static Node *stack[MaxN];
101     int top = 0;
102     stack[top++] = x;
103     for (Node *y = x; !isRoot(y); y = y->p)
104         stack[top++] = y->p;
105     while (top)
106         Pushdown(stack[--top]);
107
108     while (!isRoot(x))
109     {
110         Node *y = x->p;
111         if (isRoot(y))
112             Rotate(x, x == y->c[0]);
113         else
114         {
115             int fd = y->p->c[0] == y;
116             if (y->c[fd] == x)
117                 Rotate(x, fd ^ 1), Rotate(x, fd);
118             else
119                 Rotate(y, fd), Rotate(x, fd);
120         }
121     }
122     Pushup(x);
123 }
124 Node *Access(Node *u)
125 {
126     Node *v = nil;
127     while (u != nil)
128     {
129         Splay(u);
130         v->p = u;
131         u->c[1] = v;
132         Pushup(u);
133         u = (v = u)->p;
134         if (u == nil)
135             return v;
136     }
137 }
138 Node *LCA(Node *u, Node *v)
139 {
140     Access(u);
141     return Access(v);
142 }
143 Node *Link(Node *u, Node *v)
144 {
145     Access(u);
146     Splay(u);

```

```

147         u->rev = true;
148         u->p = v;
149     }
150     void ChangeRoot(Node *u)
151     {
152         Access(u)->rev ^= 1;
153     }
154     Node *GetRoute(Node *u, Node *v)
155     {
156         ChangeRoot(u);
157         return Access(v);
158     }
159 };
160
161 int n, m;
162 SplayTree sp;
163
164 int main(int argc, char const *argv[])
165 {
166     while (scanf("%d", &n) != EOF)
167     {
168         Init();
169         for (int i = 0; i < n; i++)
170         {
171             int v;
172             scanf("%d", &v);
173             pos[i] = newNode(v, nil);
174         }
175         for (int i = 0; i < n - 1; i++)
176         {
177             int u, v;
178             scanf("%d%d", &u, &v);
179             u--, v--;
180             sp.Link(pos[u], pos[v]);
181         }
182
183         //         scanf("%d", &m);
184         //         for (int i = 0; i < m; i++)
185         //         {
186         //             int typ, u, v, c;
187         //             scanf("%d%d%d", &typ, &u, &v);
188         //             u--, v--;
189         //             if (typ == 1)
190         //                 printf("%d\n", sp.GetRoute(pos[u], pos[v])->maxsum);
191         //             else
192         //             {
193         //                 scanf("%d", &c);
194         //                 Node *p = sp.GetRoute(pos[u], pos[v]);
195         //                 p->same = true;
196         //                 p->sa = c;
197         //             }
198         //         }
199     }
200     return 0;
201 }

```

### 5.3 可持久化线段树

区间第 $k$ 小数，内存压缩版，POJ2014。

```

1 #include <cstdio>
2 #include <algorithm>
3 using namespace std;

```

```

4
5 const int MAXN=100000,MAXM=100000;
6
7 struct node
8 {
9     node *l,*r;
10    int sum;
11 }tree[MAXN*4+MAXM*20];
12
13 int N;
14 node *newnode()
15 {
16     tree[N].l=tree[N].r=NULL;
17     tree[N].sum=0;
18     return &tree[N++];
19 }
20 node *newnode(node *x)
21 {
22     tree[N].l=x->l;
23     tree[N].r=x->r;
24     tree[N].sum=x->sum;
25     return &tree[N++];
26 }
27 node *build(int l,int r)
28 {
29     node *x=newnode();
30     if (l<r)
31     {
32         int mid=l+r>>1;
33         x->l=build(l,mid);
34         x->r=build(mid+1,r);
35         x->sum=x->l->sum+x->r->sum;
36     }
37     else
38         x->sum=0;
39     return x;
40 }
41 node *update(node *x,int l,int r,int p,int v)
42 {
43     if (l<r)
44     {
45         int mid=l+r>>1;
46         node *nx=newnode(x);
47         if (p<=mid)
48         {
49             node *ret=update(x->l,l,mid,p,v);
50             nx->l=ret;
51         }
52         else
53         {
54             node *ret=update(x->r,mid+1,r,p,v);
55             nx->r=ret;
56         }
57         nx->sum=nx->l->sum+nx->r->sum;
58         return nx;
59     }
60     else
61     {
62         node *nx=newnode(x);
63         nx->sum+=v;
64         return nx;
65     }
66 }

```

```

67 int query(node *x1,node *x2,int l,int r,int k)
68 {
69     if (l<r)
70     {
71         int mid=l+r>>1;
72         int lsum=x2->l->sum-x1->l->sum;
73         if (lsum>=k)
74             return query(x1->l,x2->l,l,mid,k);
75         else
76             return query(x1->r,x2->r,mid+1,r,k-lsum);
77     }
78     else
79         return l;
80 }
81 char s[10];
82 node *root[MAXM+1];
83 int a[MAXN],b[MAXN];
84 int init(int n)
85 {
86     for (int i=0;i<n;i++)
87         b[i]=a[i];
88     sort(b,b+n);
89     int tn=unique(b,b+n)-b;
90     for (int i=0;i<n;i++)
91     {
92         int l=0,r=tn-1;
93         while (l<r)
94         {
95             int mid=l+r>>1;
96             if (b[mid]>=a[i])
97                 r=mid;
98             else
99                 l=mid+1;
100         }
101         a[i]=l;
102     }
103     return tn;
104 }
105 int main()
106 {
107     int cas=1,n;
108     while (scanf("%d",&n)!=EOF)
109     {
110         printf("Case_␣%d:\n",cas++);
111         for (int i=0;i<n;i++)
112             scanf("%d",&a[i]);
113         int tn=init(n);
114         N=0;
115         root[0]=build(0,tn-1);
116         for (int i=1;i<=n;i++)
117             root[i]=update(root[i-1],0,tn-1,a[i-1],1);
118         int m;
119         scanf("%d",&m);
120         for (int i=0;i<m;i++)
121         {
122             int s,t;
123             scanf("%d%d",&s,&t);
124             printf("%d\n",b[query(root[s-1],root[t],0,tn-1,t-s+2>>1)]);
125         }
126     }
127     return 0;
128 }

```

## 5.4 treap正式版

支持翻转。

```
1 #include <cstdio>
2 #include <cstdlib>
3 #include <algorithm>
4 using namespace std;
5
6 const int MAXN = 100000;
7 const int MAXM = 100000;
8 const int inf = 0x7fffffff;
9 int a[MAXN];
10 struct Treap
11 {
12     int N;
13     Treap()
14     {
15         N = 0;
16         root = NULL;
17     }
18     void init()
19     {
20         N = 0;
21         root = NULL;
22     }
23     struct Treap_Node
24     {
25         Treap_Node *son[2]; //left & right
26         int value, fix;
27         bool lazy;
28         int size;
29         Treap_Node() {}
30         Treap_Node(int _value)
31         {
32             son[0] = son[1] = NULL;
33             value = _value;
34             fix = rand() * rand();
35             lazy = 0;
36             size = 1;
37         }
38         int sonSize(bool flag)
39         {
40             if (son[flag] == NULL)
41                 return 0;
42             else
43                 return son[flag]->size;
44         }
45     } node[MAXN], *root, *pos[MAXN];
46     void up(Treap_Node *p)
47     {
48         p->size = p->sonSize(0) + p->sonSize(1) + 1;
49     }
50     void down(Treap_Node *p)
51     {
52         if (!p->lazy)
53             return ;
54         for (int i = 0; i < 2; i++)
55             if (p->son[i])
56                 p->son[i]->lazy = !p->son[i]->lazy;
57         swap(p->son[0], p->son[1]);
58         p->lazy = 0;
59     }
60     Treap_Node *merge(Treap_Node *p, Treap_Node *q)
```



```

61     {
62         if (p == NULL)
63             return q;
64         else if (q == NULL)
65             return p;
66         if (p->fix <= q->fix)
67         {
68             down(p);
69             p->son[1] = merge(p->son[1], q);
70             up(p);
71             return p;
72         }
73         else
74         {
75             down(q);
76             q->son[0] = merge(p, q->son[0]);
77             up(q);
78             return q;
79         }
80     }
81 pair<Treap_Node *, Treap_Node *> split(Treap_Node *p, int n)
82 {
83     if (p == NULL)
84         return make_pair((Treap_Node *)NULL, (Treap_Node *)NULL);
85     if (!n)
86         return make_pair((Treap_Node *)NULL, p);
87     if (n == p->size)
88         return make_pair(p, (Treap_Node *)NULL);
89     down(p);
90     if (p->sonSize(0) >= n)
91     {
92         pair<Treap_Node *, Treap_Node *> ret = split(p->son[0], n);
93         p->son[0] = ret.second;
94         up(p);
95         return make_pair(ret.first, p);
96     }
97     else
98     {
99         pair<Treap_Node *, Treap_Node *> ret = split(p->son[1], n - p->
100             sonSize(0) - 1);
101         p->son[1] = ret.first;
102         up(p);
103         return make_pair(p, ret.second);
104     }
105 }
106 int smalls(Treap_Node *p, int value)
107 {
108     if (p==NULL)
109         return 0;
110     if (p->value<=value)
111         return 1+p->sonSize(0)+smalls(p->son[1], value);
112     else
113         return smalls(p->son[0], value);
114 }
115 void insert(int value)
116 {
117     Treap_Node *p = &node[N++];
118     *p = Treap_Node(value);
119     pair<Treap_Node *, Treap_Node *> ret = split(root, smalls(root,
120         value));
121     root = merge(merge(ret.first, p), ret.second);
122 }
123 void remove(int value)

```

```

122     {
123         pair<Treap_Node *, Treap_Node *> ret = split(root, smalls(root,
124             value) - 1);
125         root = merge(ret.first, split(ret.second, 1).second);
126     }
127     Treap_Node *build(int s, int t)
128     {
129         int idx = t + s >> 1;
130         Treap_Node *p = &node[N++];
131         *p = Treap_Node(a[idx]);
132         pos[a[idx]] = p;
133         if (idx > s)
134             p = merge(build(s, idx - 1), p);
135         if (idx < t)
136             p = merge(p, build(idx + 1, t));
137         up(p);
138         return p;
139     }
140     void build(int n)
141     {
142         root = build(0, n - 1);
143     }
144     void *reverse(int s, int t)
145     {
146         pair<Treap_Node *, Treap_Node *> tmp1, tmp2;
147         tmp1 = split(root, s - 1);
148         tmp2 = split(tmp1.second, t - s + 1);
149         tmp2.first->lazy = !tmp2.first->lazy;
150         root = merge(tmp1.first, merge(tmp2.first, tmp2.second));
151     }
152 };
153 Treap treap;
154 int main()
155 {
156     treap.init();
157     int n;
158     scanf("%d", &n);
159     for (int i = 0; i < n; i++)
160         scanf("%d", &a[i]);
161     treap.build(n);
162 }

```

## 5.5 树链剖分

### 5.5.1 点权

```

1  #include <cstdio>
2  #include <cstring>
3  #include <cstdlib>
4  #include <algorithm>
5  using namespace std;
6  const int MAX = 12000;
7  const int LOG = 15;
8  const int oo = 0x3f3f3f3f;
9  struct Edge
10 {
11     int to, w, id;
12     Edge* next;
13 } memo[MAX << 1], *cur, *g[MAX], *pree[MAX], *solid[MAX], *valid[MAX];
14 int dp[MAX][LOG], pos[MAX], lst[MAX], dep[MAX], cnt[MAX], h[MAX], K, n;
15 void init()
16 {
17     for (int i = 1; i <= n; i++)

```

```

18     {
19         g[i] = NULL;
20         valid[i] = NULL;
21         solid[i] = NULL;
22         pree[i] = NULL;
23     }
24     for (int i = 0; i < LOG; i++)
25     {
26         dp[1][i] = 1;
27     }
28     cur = memo;
29     K = 0;
30 }
31 void add(int u, int v, int w, int id)
32 {
33     cur->to = v;
34     cur->w = w;
35     cur->id = id;
36     cur->next = g[u];
37     g[u] = cur++;
38 }
39 void dfsLCA(int d, int u, int f)
40 {
41     dep[u] = d;
42     dp[u][0] = f;
43     cnt[u] = 1;
44     for (int i = 1; i < LOG; i++)
45     {
46         dp[u][i] = dp[dp[u][i - 1]][i - 1];
47     }
48     for (Edge* it = g[u]; it; it = it->next)
49     {
50         int v = it->to;
51         if (v != f)
52         {
53             pree[v] = it;
54             valid[it->id] = it;
55             dfsLCA(d + 1, v, u); //RE
56             cnt[u] += cnt[v];
57             if (solid[u] == NULL || cnt[solid[u]->to] < cnt[v])
58             {
59                 solid[u] = it;
60             }
61         }
62     }
63 }
64 void dfsChain(int u, int head)
65 {
66     h[u] = head;
67     if (solid[u])
68     {
69         lst[pos[u] = K++] = u;
70         dfsChain(solid[u]->to, head);
71     }
72     else
73     for (Edge* it = g[u]; it; it = it->next)
74     {
75         int v = it->to;
76         if (it != solid[u] && v != dp[u][0])
77         {
78             dfsChain(v, v);
79         }
80     }

```

```

81 }
82 int getLCA(int u, int v)
83 {
84     if (dep[u] < dep[v])
85         swap(u, v);
86     for (int st = 1 << (LOG - 1), i = LOG - 1; i >= 0; i--, st >>= 1)
87     {
88         if (st <= dep[u] - dep[v])
89         {
90             u = dp[u][i];
91         }
92     }
93     if (u == v)
94         return u;
95     for (int i = LOG - 1; i >= 0; i--)
96     {
97         if (dp[u][i] != dp[v][i])
98         {
99             u = dp[u][i];
100            v = dp[v][i];
101        }
102    }
103    return dp[u][0];
104 }
105 struct Node
106 {
107     int l, r, ma, mi;
108     bool rev;
109 } seg[MAX << 2];
110 void reverse(int k)
111 {
112     seg[k].mi *= -1;
113     seg[k].ma *= -1;
114     seg[k].rev ^= 1;
115     swap(seg[k].mi, seg[k].ma);
116 }
117 void pushdown(int k)
118 {
119     if (seg[k].rev)
120     {
121         reverse(k << 1);
122         reverse(k << 1 | 1);
123         seg[k].rev = false;
124     }
125 }
126 void update(int k)
127 {
128     seg[k].mi = min(seg[k << 1].mi, seg[k << 1 | 1].mi);
129     seg[k].ma = max(seg[k << 1].ma, seg[k << 1 | 1].ma);
130 }
131 void init(int k, int l, int r)
132 {
133     seg[k].l = l;
134     seg[k].r = r;
135     seg[k].rev = false;
136     if (l == r)
137     {
138         seg[k].mi = seg[k].ma = solid[lst[l]]->w; //solid WA
139         return;
140     }
141     int mid = l + r >> 1;
142     init(k << 1, l, mid);
143     init(k << 1 | 1, mid + 1, r);

```

```

144     update(k);
145 }
146 void update(int k, int id, int v)
147 {
148     if (seg[k].l == seg[k].r)
149     {
150         seg[k].mi = seg[k].ma = solid[1st[id]]->w = v;
151         return;
152     }
153     pushdown(k);
154     int mid = seg[k].l + seg[k].r >> 1;
155     if (id <= mid)
156         update(k << 1, id, v);
157     else
158         update(k << 1 | 1, id, v);
159     update(k);
160 }
161 void reverse(int k, int l, int r)
162 {
163     if (seg[k].l > r || seg[k].r < l)
164         return;
165     if (seg[k].l >= l && seg[k].r <= r)
166     {
167         reverse(k);
168         return;
169     }
170     pushdown(k);
171     reverse(k << 1, l, r);
172     reverse(k << 1 | 1, l, r);
173     update(k);
174 }
175 int read(int k, int l, int r)
176 {
177     if (seg[k].l > r || seg[k].r < l)
178         return -oo;
179     if (seg[k].l >= l && seg[k].r <= r)
180         return seg[k].ma;
181     pushdown(k);
182     return max(read(k << 1, l, r), read(k << 1 | 1, l, r));
183 }
184 void setEdge(int id, int v)
185 {
186     Edge* it = valid[id];
187     if (h[it->to] != it->to)
188     {
189         update(1, pos[dp[it->to][0]], v);
190     }
191     else
192     {
193         it->w = v;
194     }
195 }
196 void negateLCA(int t, int u)
197 {
198     while (t != u)
199     {
200         int tmp = h[u];
201         if (dep[tmp] < dep[t])
202             tmp = t;
203         if (h[u] == u)
204         {
205             pree[u]->w *= -1;
206             u = dp[u][0];

```

```

207         }
208         else
209         {
210             reverse(1, pos[tmp], pos[dp[u][0]]);
211             u = tmp;
212         }
213     }
214 }
215 void negate(int u, int v)
216 {
217     int t = getLCA(u, v);
218     negateLCA(t, u);
219     negateLCA(t, v);
220 }
221 int maxLCA(int t, int u)
222 {
223     int ret = -oo;
224     while (t != u)
225     {
226         int tmp = h[u];
227         if (dep[tmp] < dep[t])
228             tmp = t;
229         if (h[u] == u)
230         {
231             ret = max(ret, pree[u]->w);
232             u = dp[u][0];
233         }
234         else
235         {
236             ret = max(ret, read(1, pos[tmp], pos[dp[u][0]]));
237             u = tmp;
238         }
239     }
240     return ret;
241 }
242 int query(int u, int v)
243 {
244     int t = getLCA(u, v);
245     return max(maxLCA(t, u), maxLCA(t, v));
246 }
247 int main()
248 {
249     int T;
250     int u, v, w;
251     char op[15];
252     scanf("%d", &T);
253     while (T--)
254     {
255         scanf("%d", &n);
256         init();
257         for (int i = 1; i < n; i++)
258         {
259             scanf("%d%d%d", &u, &v, &w);
260             add(u, v, w, i);
261             add(v, u, w, i);
262         }
263         dfsLCA(0, 1, 1);
264         dfsChain(1, 1);
265         init(1, 0, K - 1);
266         while (scanf("%s", op), op[0] != 'D')
267         {
268             scanf("%d%d", &u, &v);
269             if (op[0] == 'C')

```

```

270         {
271             setEdge(u, v);
272         }
273         else if (op[0] == 'N')
274         {
275             negate(u, v);
276         }
277         else
278         {
279             printf("%d\n", query(u, v));
280         }
281     }
282 }
283 return 0;
284 }

```

### 5.5.2 边权

```

1  #include <cstdio>
2  #include <iostream>
3  #include <cstdlib>
4  #include <algorithm>
5  #include <cmath>
6  #include <cstring>
7  using namespace std;
8  int n,m,sum,pos;
9  int head[50005],e;
10 int s[50005],from[50005];
11 int fa[50005][20],deep[50005],num[50005];
12 int solid[50005],p[50005],fp[50005];
13 struct N
14 {
15     int l,r,mid;
16     int add,w;
17 }nod[50005*4];
18 struct M
19 {
20     int v,next;
21 }edge[100005];
22 void addedge(int u,int v)
23 {
24     edge[e].v=v;
25     edge[e].next=head[u];
26     head[u]=e++;
27
28     edge[e].v=u;
29     edge[e].next=head[v];
30     head[v]=e++;
31 }
32 void LCA(int st,int f,int d)
33 {
34     deep[st]=d;
35     fa[st][0]=f;
36     num[st]=1;
37     int i,v;
38     for(i=1;i<20;i++)
39         fa[st][i]=fa[fa[st][i-1]][i-1];
40     for(i=head[st];i!=-1;i=edge[i].next)
41     {
42         v=edge[i].v;
43         if(v!=f)
44         {
45             LCA(v,st,d+1);
46             num[st]+=num[v];

```

```

47         if(solid[st]==-1||num[v]>num[solid[st]])
48             solid[st]=v;
49     }
50 }
51 }
52 void getpos(int st,int sp)
53 {
54     from[st]=sp;
55     if(solid[st]!=-1)
56     {
57         p[st]=pos++;
58         fp[p[st]]=st;
59         getpos(solid[st],sp);
60     }
61     else
62     {
63         p[st]=pos++;
64         fp[p[st]]=st;
65         return;
66     }
67     int i,v;
68     for(i=head[st];i!=-1;i=edge[i].next)
69     {
70         v=edge[i].v;
71         if(v!=solid[st]&&v!=fa[st][0])
72             getpos(v,v);
73     }
74 }
75 int getLCA(int u,int v)
76 {
77     if(deep[u]<deep[v])
78         swap(u,v);
79     int d=1<<19,i;
80     for(i=19;i>=0;i--)
81     {
82         if(d<=deep[u]-deep[v])
83             u=fa[u][i];
84         d>>=1;
85     }
86     if(u==v)
87         return u;
88     for(i=19;i>=0;i--)
89         if(fa[u][i]!=fa[v][i])
90         {
91             u=fa[u][i];
92             v=fa[v][i];
93         }
94     return fa[u][0];
95 }
96 void init(int p,int l,int r)
97 {
98     nod[p].l=l;
99     nod[p].r=r;
100     nod[p].mid=(l+r)>>1;
101     nod[p].add=0;
102     if(l==r)
103         nod[p].w=s[fp[l]];
104     else
105     {
106         init(p<<1,l,nod[p].mid);
107         init(p<<1|1,nod[p].mid+1,r);
108     }
109 }

```



```

110 void lazy(int p)
111 {
112     if(nod[p].add!=0)
113     {
114         nod[p<<1].add+=nod[p].add;
115         nod[p<<1|1].add+=nod[p].add;
116         nod[p].add=0;
117     }
118 }
119 void update(int p,int l,int r,int v)
120 {
121     if(nod[p].l==l&&nod[p].r==r)
122     {
123         nod[p].add+=v;
124         return;
125     }
126     lazy(p);
127     if(nod[p].mid<l)
128         update(p<<1|1,l,r,v);
129     else if(nod[p].mid>=r)
130         update(p<<1,l,r,v);
131     else
132     {
133         update(p<<1,l,nod[p].mid,v);
134         update(p<<1|1,nod[p].mid+1,r,v);
135     }
136 }
137 int read(int p,int l,int r)
138 {
139     if(nod[p].l==l&&nod[p].r==r)
140         return nod[p].w+nod[p].add;
141     lazy(p);
142     if(nod[p].mid<l)
143         return read(p<<1|1,l,r);
144     else if(nod[p].mid>=r)
145         return read(p<<1,l,r);
146 }
147 void jump(int st,int ed,int val)
148 {
149     while(deep[st]>=deep[ed])
150     {
151         int tmp=from[st];
152         if(deep[tmp]<deep[ed])
153             tmp=ed;
154         update(1,p[tmp],p[st],val);
155         st=fa[tmp][0];
156     }
157 }
158 void change(int st,int ed,int val)
159 {
160     int lca=getLCA(st,ed);
161     jump(st,lca,val);
162     jump(ed,lca,val);
163     jump(lca,lca,-val);
164 }
165 int main()
166 {
167     while(scanf("%d%d%d",&n,&m,&sum)==3)
168     {
169         int i;
170         s[0]=0;pos=0;deep[0]=-1;
171         memset(fa,0,sizeof(fa));
172         for(i=1;i<=n;i++)

```

```

173     {
174         solid[i]=-1;
175         scanf("%d",&s[i]);
176     }
177     memset(head,-1,sizeof(head));
178     e=0;
179     for(i=0;i<m;i++)
180     {
181         int a,b;
182         scanf("%d%d",&a,&b);
183         addedge(a,b);
184     }
185     LCA(1,0,0);
186     getpos(1,1);
187     init(1,0,pos-1);
188     for(i=0;i<sum;i++)
189     {
190         char que[5];
191         scanf("%s",que);
192         if(que[0]!='Q')
193         {
194             int a,b,c;
195             scanf("%d%d%d",&a,&b,&c);
196             if(que[0]=='D')
197                 c=-c;
198             change(a,b,c);
199         }
200         else
201         {
202             int a;
203             scanf("%d",&a);
204             printf("%d\n",read(1,p[a],p[a]));
205         }
206     }
207 }
208 return 0;
209 }

```

## 6 图论

### 6.1 SAP四版

```
1  const int MAXEDGE=20400;
2  const int MAXN=400;
3  const int inf=0x3fffffff;
4  struct edges
5  {
6      int cap,to,next,flow;
7  } edge[MAXEDGE+100];
8  struct nodes
9  {
10     int head,label,pre,cur;
11 } node[MAXN+100];
12 int L,N;
13 int gap[MAXN+100];
14 void init(int n)
15 {
16     L=0;
17     N=n;
18     for (int i=0; i<N; i++)
19         node[i].head=-1;
20 }
21 void add_edge(int x,int y,int z,int w)
22 {
23     edge[L].cap=z;
24     edge[L].flow=0;
25     edge[L].to=y;
26     edge[L].next=node[x].head;
27     node[x].head=L++;
28     edge[L].cap=w;
29     edge[L].flow=0;
30     edge[L].to=x;
31     edge[L].next=node[y].head;
32     node[y].head=L++;
33 }
34 int maxflow(int s,int t)
35 {
36     memset(gap,0,sizeof(gap));
37     gap[0]=N;
38     int u,ans=0;
39     for (int i=0; i<N; i++)
40     {
41         node[i].cur=node[i].head;
42         node[i].label=0;
43     }
44     u=s;
45     node[u].pre=-1;
46     while (node[s].label<N)
47     {
48         if (u==t)
49         {
50             int min=inf;
51             for (int i=node[u].pre; i!=-1; i=node[edge[i^1].to].pre)
52                 if (min>edge[i].cap-edge[i].flow)
53                     min=edge[i].cap-edge[i].flow;
54             for (int i=node[u].pre; i!=-1; i=node[edge[i^1].to].pre)
55             {
56                 edge[i].flow+=min;
57                 edge[i^1].flow-=min;
58             }
59             u=s;
```

```

60         ans+=min;
61         continue;
62     }
63     bool flag=false;
64     int v;
65     for (int i=node[u].cur; i!=-1; i=edge[i].next)
66     {
67         v=edge[i].to;
68         if (edge[i].cap-edge[i].flow && node[v].label+1==node[u].label)
69         {
70             flag=true;
71             node[u].cur=node[v].pre=i;
72             break;
73         }
74     }
75     if (flag)
76     {
77         u=v;
78         continue;
79     }
80     node[u].cur=node[u].head;
81     int min=N;
82     for (int i=node[u].head; i!=-1; i=edge[i].next)
83         if (edge[i].cap-edge[i].flow && node[edge[i].to].label<min)
84             min=node[edge[i].to].label;
85     gap[node[u].label]--;
86     if (!gap[node[u].label]) return ans;
87     node[u].label=min+1;
88     gap[node[u].label]++;
89     if (u!=s) u=edge[node[u].pre^1].to;
90 }
91 return ans;
92 }

```

## 6.2 费用流三版

T了可以改成栈。

```

1  const int MAXM=60000;
2  const int MAXN=400;
3  const int inf=0x3fffffff;
4  int L,N;
5  int K;
6  struct edges
7  {
8      int to,next,cap,flow,cost;
9  } edge[MAXM];
10 struct nodes
11 {
12     int dis,pre,head;
13     bool visit;
14 } node[MAXN];
15 void init(int n)
16 {
17     N=n;
18     L=0;
19     for (int i=0; i<N; i++)
20         node[i].head=-1;
21 }
22 void add_edge(int x,int y,int cap,int cost)
23 {
24     edge[L].to=y;
25     edge[L].cap=cap;
26     edge[L].cost=cost;

```

```

27     edge[L].flow=0;
28     edge[L].next=node[x].head;
29     node[x].head=L++;
30     edge[L].to=x;
31     edge[L].cap=0;
32     edge[L].cost=-cost;
33     edge[L].flow=0;
34     edge[L].next=node[y].head;
35     node[y].head=L++;
36 }
37 bool spfa(int s,int t)
38 {
39     queue <int> q;
40     for (int i=0; i<N; i++)
41     {
42         node[i].dis=0x3fffffff;
43         node[i].pre=-1;
44         node[i].visit=0;
45     }
46     node[s].dis=0;
47     node[s].visit=1;
48     q.push(s);
49     while (!q.empty())
50     {
51         int u=q.front();
52         node[u].visit=0;
53         for (int i=node[u].head; i!=-1; i=edge[i].next)
54         {
55             int v=edge[i].to;
56             if (edge[i].cap>edge[i].flow &&
57                 node[v].dis>node[u].dis+edge[i].cost)
58             {
59                 node[v].dis=node[u].dis+edge[i].cost;
60                 node[v].pre=i;
61                 if (!node[v].visit)
62                 {
63                     node[v].visit=1;
64                     q.push(v);
65                 }
66             }
67         }
68         q.pop();
69     }
70     if (node[t].pre==-1)
71         return 0;
72     else
73         return 1;
74 }
75 int mcmf(int s,int t,int &cost)
76 {
77     int flow=0;
78     while (spfa(s,t))
79     {
80         int max=inf;
81         for (int i=node[t].pre; i!=-1; i=node[edge[i^1].to].pre)
82         {
83             if (max>edge[i].cap-edge[i].flow)
84                 max=edge[i].cap-edge[i].flow;
85         }
86         for (int i=node[t].pre; i!=-1; i=node[edge[i^1].to].pre)
87         {
88             edge[i].flow+=max;
89             edge[i^1].flow-=max;

```

```

90         cost+=edge[i].cost*max;
91     }
92     flow+=max;
93 }
94 return flow;
95 }

```

### 6.3 一般图匹配带花树

```

1  const int MaxN = 222;
2  int N;
3  bool Graph[MaxN+1][MaxN+1];
4  int Match[MaxN+1];
5  bool InQueue[MaxN+1], InPath[MaxN+1], InBlossom[MaxN+1];
6  int Head, Tail;
7  int Queue[MaxN+1];
8  int Start, Finish;
9  int NewBase;
10 int Father[MaxN+1], Base[MaxN+1];
11 int Count;
12 void CreateGraph()
13 {
14     int u, v;
15     memset(Graph, false, sizeof(Graph));
16     scanf("%d", &N);
17     while (scanf("%d%d", &u, &v) != EOF)
18         Graph[u][v] = Graph[v][u] = true;
19 }
20 void Push(int u)
21 {
22     Queue[Tail] = u;
23     Tail++;
24     InQueue[u] = true;
25 }
26 int Pop()
27 {
28     int res = Queue[Head];
29     Head++;
30     return res;
31 }
32 int FindCommonAncestor(int u, int v)
33 {
34     memset(InPath, false, sizeof(InPath));
35     while (true)
36     {
37         u = Base[u];
38         InPath[u] = true;
39         if (u == Start) break;
40         u = Father[Match[u]];
41     }
42     while (true)
43     {
44         v = Base[v];
45         if (InPath[v]) break;
46         v = Father[Match[v]];
47     }
48     return v;
49 }
50 void ResetTrace(int u)
51 {
52     int v;
53     while (Base[u] != NewBase)

```

```

54     {
55         v = Match[u];
56         InBlossom[Base[u]] = InBlossom[Base[v]] = true;
57         u = Father[v];
58         if (Base[u] != NewBase) Father[u] = v;
59     }
60 }
61 void BlossomContract(int u,int v)
62 {
63     NewBase = FindCommonAncestor(u,v);
64     memset(InBlossom,false,sizeof(InBlossom));
65     ResetTrace(u);
66     ResetTrace(v);
67     if (Base[u] != NewBase) Father[u] = v;
68     if (Base[v] != NewBase) Father[v] = u;
69     for (int tu = 1; tu <= N; tu++)
70         if (InBlossom[Base[tu]])
71             {
72                 Base[tu] = NewBase;
73                 if (!InQueue[tu]) Push(tu);
74             }
75 }
76 void FindAugmentingPath()
77 {
78     memset(InQueue,false,sizeof(InQueue));
79     memset(Father,0,sizeof(Father));
80     for (int i = 1; i <= N; i++)
81         Base[i] = i;
82     Head = Tail = 1;
83     Push(Start);
84     Finish = 0;
85     while (Head < Tail)
86     {
87         int u = Pop();
88         for (int v = 1; v <= N; v++)
89             if (Graph[u][v] && (Base[u] != Base[v]) && (Match[u] != v))
90                 {
91                     if ((v == Start) || ((Match[v] > 0) && (Father[Match[v]] >
92                         0)))
93                         BlossomContract(u,v);
94                     else if (Father[v] == 0)
95                     {
96                         Father[v] = u;
97                         if (Match[v] > 0)
98                             Push(Match[v]);
99                     }
100                     else
101                     {
102                         Finish = v;
103                         return;
104                     }
105                 }
106     }
107 void AugmentPath()
108 {
109     int u,v,w;
110     u = Finish;
111     while (u > 0)
112     {
113         v = Father[u];
114         w = Match[v];
115         Match[v] = u;

```

```

116         Match[u] = v;
117         u = w;
118     }
119 }
120 void Edmonds()
121 {
122     memset(Match,0,sizeof(Match));
123     for (int u = 1; u <= N; u++)
124         if (Match[u] == 0)
125         {
126             Start = u;
127             FindAugmentingPath();
128             if (Finish > 0) AugmentPath();
129         }
130 }
131 void PrintMatch()
132 {
133     for (int u = 1; u <= N; u++)
134         if (Match[u] > 0)
135             Count++;
136     printf("%d\n",Count);
137     for (int u = 1; u <= N; u++)
138         if (u < Match[u])
139             printf("%d□%d\n",u,Match[u]);
140 }
141 int main()
142 {
143     CreateGraph();
144     Edmonds();
145     PrintMatch();
146 }

```

## 6.4 \*二维平面图的最大流

待整理

```

1  #include <iostream>
2  #include <algorithm>
3  #include <cstdio>
4  #include <cstring>
5  #include <vector>
6  #include <cmath>
7  #include <map>
8  #include <queue>
9  using namespace std;
10
11 const int maxn = 100100;
12 const int inf = 0x3f3f3f3f;
13 struct Point
14 {
15     int x,y,id;
16     double theta;
17     Point() {}
18     Point(int _x,int _y)
19     {
20         x = _x;
21         y = _y;
22     }
23     Point(Point _s,Point _e,int _id)
24     {
25         id = _id;
26         x = _s.x-_e.x;
27         y = _s.y-_e.y;
28         theta = atan2(y,x);

```



```

29     }
30     bool operator < (const Point &b) const
31     {
32         return theta < b.theta;
33     }
34 };
35
36 map<pair<int,int>,int > idmap;
37 struct Edge
38 {
39     int from,to,next,cap,near,mark;
40 };
41 Edge edge[maxn*2];
42 int head[maxn],L;
43 int cntd[maxn];
44 void addedge(int u,int v,int cap)
45 {
46     cntd[u]++;
47     cntd[v]++;
48     idmap[make_pair(u,v)] = L;
49     edge[L].from = u;
50     edge[L].to = v;
51     edge[L].cap = cap;
52     edge[L].next = head[u];
53     edge[L].mark = -1;
54     head[u] = L++;
55 }
56
57 int rtp[maxn];
58 Point p[maxn],tp[maxn];
59 int n,m,S,T;
60 int vid;
61
62 struct Edge2
63 {
64     int to,next,dis;
65 } edge2[maxn*2];
66 int head2[maxn],L2;
67
68 void addedge2(int u,int v,int dis)
69 {
70     edge2[L2].to = v;
71     edge2[L2].dis = dis;
72     edge2[L2].next = head2[u];
73     head2[u] = L2++;
74 }
75
76 int dist[maxn];
77 bool inq[maxn];
78 int SPFA(int s,int t)
79 {
80     queue<int> Q;
81     memset(inq,false,sizeof(inq));
82     memset(dist,63,sizeof(dist));
83     Q.push(s);
84     dist[s] = 0;
85     while (!Q.empty())
86     {
87         int now = Q.front();
88         Q.pop();
89         for (int i = head2[now]; i != -1; i = edge2[i].next)
90             if (dist[edge2[i].to] > dist[now]+edge2[i].dis)
91                 {

```

```

92         dist[edge2[i].to] = dist[now]+edge2[i].dis;
93         if (inq[edge2[i].to] == false)
94         {
95             inq[edge2[i].to] = true;
96             Q.push(edge2[i].to);
97         }
98     }
99     inq[now] = false;
100 }
101 return dist[t];
102 }
103
104 int main()
105 {
106     int totcas;
107     scanf("%d",&totcas);
108     for (int cas = 1; cas <= totcas; cas++)
109     {
110         idmap.clear();
111         L = 0;
112         scanf("%d%d",&n,&m);
113         S = T = 0;
114         for (int i = 0; i < n; i++)
115         {
116             head[i] = -1;
117             scanf("%d%d",&p[i].x,&p[i].y);
118             if (p[S].x > p[i].x)
119                 S = i;
120             if (p[T].x < p[i].x)
121                 T = i;
122             cntd[i] = 0;
123         }
124         //源汇中间加入一个特殊节点
125         head[n] = -1;
126         n ++;
127         addedge(S,n-1,inf);
128         addedge(n-1,S,inf);
129         addedge(T,n-1,inf);
130         addedge(n-1,T,inf);
131
132         for (int i = 0; i < m; i++)
133         {
134             int u,v,cap;
135             scanf("%d%d%d",&u,&v,&cap);
136             u--;
137             v--;
138             addedge(u,v,cap);
139             addedge(v,u,cap);
140         }
141
142         for (int i = 0; i < n; i++)
143         {
144             int tot = 0;
145             //源点汇点连到特殊点的方向需要特别考虑一下
146             if (i == S)
147                 tp[tot++] = Point(Point(0,0),Point(-1,0),n-1);
148             else if (i == T)
149                 tp[tot++] = Point(Point(0,0),Point(1,0),n-1);
150             else if (i == n-1)
151             {
152                 tp[tot++] = Point(Point(0,0),Point(1,0),S);
153                 tp[tot++] = Point(Point(0,0),Point(-1,0),T);
154             }

```

```

155         if (i < n-1)
156         {
157             for (int j = head[i]; j != -1; j = edge[j].next)
158             {
159                 if (i == S && edge[j].to == n-1) continue;
160                 if (i == T && edge[j].to == n-1) continue;
161                 tp[tot++] = Point(p[i],p[edge[j].to],edge[j].to);
162             }
163         }
164         sort(tp,tp+tot);
165         for (int j = 0; j < tot; j++)
166             rtp[tp[j].id] = j;
167         for (int j = head[i]; j != -1; j = edge[j].next)
168             edge[j].near = tp[(rtp[edge[j].to]+1)%tot].id;
169     }
170
171     vid = 0;
172     for (int i = 0; i < L; i++)
173         if (edge[i].mark == -1)
174         {
175             int now = edge[i].from;
176             int eid = i;
177             int to = edge[i].to;
178             while (true)
179             {
180                 edge[eid].mark = vid;
181                 eid ^= 1;
182                 now = to;
183                 to = edge[eid].near;
184                 eid = idmap[make_pair(now,to)];
185
186                 if (now == edge[i].from) break;
187             }
188             vid++;
189         }
190
191     L2 = 0;
192     for (int i = 0; i < vid; i++)
193         head2[i] = -1;
194     for (int i = 0; i < L; i++)
195         addedge2(edge[i].mark,edge[i^1].mark,edge[i].cap);
196     printf("%d\n",SPFA(edge[0].mark,edge[1].mark));
197 }
198 return 0;
199 }

```

## 6.5 强联通

hehe那弱逼的版，找个时间测一下。

```

1  int dfsnum[5005];
2  int low[5005];
3  int stack[5005];
4  int top;
5  int ans;
6  int an;
7  int be[5005];
8  int flag[5005];
9  void dfs(int x)
10 {
11     dfsnum[x]=low[x]=ans++;
12     stack[++top]=x;

```

```

13     flag[x]=1;
14     int i;
15     for(i=0;i<q[x].size();i++)
16     {
17         int y=q[x][i];
18         int j;
19         if(dfsnum[y]==-1)
20         {
21             dfs(y);
22             low[x]=min(low[x],low[y]);
23         }
24         else if(flag[y]==1)
25         {
26             low[x]=min(low[x],dfsnum[y]);
27         }
28     }
29     if(dfsnum[x]==low[x])
30     {
31         while(stack[top]!=x)
32         {
33             flag[stack[top]]=0;
34             be[stack[top]]=an;
35             top--;
36         }
37         flag[x]=0;
38         be[x]=an++;
39         top--;
40     }
41 }

```

调用:

```

1  memset(dfsnum,-1,sizeof(dfsnum));
2  memset(flag,0,sizeof(flag));
3  top=0;
4  an=0;
5  ans=0;
6  int i;
7  for(i=1;i<=n;i++) (//2*对于) n2sat
8  {
9      if(dfsnum[i]==-1)
10     {
11         dfs(i);
12     }
13 }

```

## 6.6 KM

还是hehe的版  
配合华华的KM看吧。

```

1  int w[16][16];
2  int l[16];
3  int r[16];
4  int low[16];
5  int n;
6  int flag1[16];
7  int flag[16];
8  int f[16];
9  int qw[16];
10 const int INF=100000000;
11 int ans;

```

```

12 int dfs(int x)
13 {
14     flag1[x]=1;
15     int i;
16     for(i=1;i<=n;i++)
17     {
18         if(flag[i]==0&&w[x][i]==l[x]+r[i])
19         {
20             flag[i]=1;
21             if(f[i]==0||dfs(f[i]))
22             {
23                 f[i]=x;
24                 return 1;
25             }
26         }
27         low[i]=min(low[i],w[x][i]-l[x]-r[i]);
28     } // (l[x]+r[i]-w[x][i] 最大匹配)
29     return 0;
30 }
31
32 int km(void)
33 {
34     memset(f,0,sizeof(f));
35     memset(r,0,sizeof(r));
36     int i;
37     for(i=1;i<=n;i++)
38     {
39         int j;
40         int mi=INF;
41         for(j=1;j<=n;j++)
42         {
43             if(w[i][j]<mi)
44                 mi=w[i][j];
45         }
46         l[i]=mi;
47     }
48     // 赋值为边权最大值。。最大匹配()
49     for(i=1;i<=n;i++)
50     {
51         while(1)
52         {
53             memset(flag,0,sizeof(flag));
54             memset(flag1,0,sizeof(flag1));
55             int j;
56             for(j=1;j<=n;j++)
57                 low[j]=INF;
58             if(dfs(i))
59                 break;
60             int d=INF;
61             for(j=1;j<=n;j++)
62             {
63                 if(flag[j]==0)
64                 {
65                     d=min(d,low[j]);
66                 }
67             }
68             for(j=1;j<=n;j++)
69             {
70                 if(flag1[j])
71                     l[j]+=d 为最大匹配; (-)
72                 if(flag[j])
73                     r[j]-=d (为最大匹配); +
74             }

```

```
75     }  
76 }  
77 int sum=0;  
78 int j;  
79 for(j=1;j<=n;j++)  
80 {  
81     sum+=l[j];  
82     sum+=r[j];  
83 }  
84 return sum;  
85 }
```

## 7 计算几何

太乱了尼玛。。

浮点数千万不要直接比较大小，千万要加上EPS啊混蛋。

### 7.1 基本函数

#### 7.1.1 Point定义

```
1 struct Point
2 {
3     double x, y;
4     Point() {}
5     Point(double _x, double _y)
6     {
7         x = _x, y = _y;
8     }
9     Point operator -(const Point &b) const
10    {
11        return Point(x - b.x, y - b.y);
12    }
13    double operator *(const Point &b) const
14    {
15        return x * b.y - y * b.x;
16    }
17    double operator &(const Point &b) const
18    {
19        return x * b.x + y * b.y;
20    }
21 };
```

#### 7.1.2 Line定义

```
1 struct Line
2 {
3     Point s, e;
4     double k;
5     Line() {}
6     Line(Point _s, Point _e)
7     {
8         s = _s, e = _e;
9         k = atan2(e.y - s.y, e.x - s.x);
10    }
11    Point operator &(const Line &b) const
12    {
13        Point res = s;
14        //注意：有些题目可能会有直线相交或者重合情况
15        //可以把返回值改成pair<Point,int>来返回两直线的状态。
16        double t = ((s - b.s) * (b.s - b.e)) / ((s - e) * (b.s - b.e));
17        res.x += (e.x - s.x) * t;
18        res.y += (e.y - s.y) * t;
19        return res;
20    }
21 };
```

#### 7.1.3 距离：两点距离

```
1 double dist2(Point a, Point b)
2 {
3     return (a.x - b.x) * (a.x - b.x) + (a.y - b.y) * (a.y - b.y);
4 }
```

#### 7.1.4 距离：点到线段距离

res: 点到线段最近点

```

1 double dist2(Point p1, Point p2, Point p)
2 {
3     Point res;
4     double a, b, t;
5     a = p2.x - p1.x;
6     b = p2.y - p1.y;
7     t = ((p.x - p1.x) * a + (p.y - p1.y) * b) / (a * a + b * b);
8     if (t >= 0 && t <= 1)
9     {
10         res.x = p1.x + a * t;
11         res.y = p1.y + b * t;
12     }
13     else
14     {
15         if (dist2(p, p1) < dist2(p, p2))
16             res = p1;
17         else
18             res = p2;
19     }
20     return dist2(p, res);
21 }

```

### 7.1.5 面积: 多边形

点按逆时针排序。

```

1 double CalcArea(Point p[], int n)
2 {
3     double res = 0;
4     for (int i = 0; i < n; i++)
5         res += (p[i] * p[(i + 1) % n]) / 2;
6     return res;
7 }

```

### 7.1.6 判断: 线段相交

```

1 bool inter(Line l1, Line l2)
2 {
3     return (max(l1.s.x, l1.e.x) >= min(l2.s.x, l2.e.x) &&
4             max(l2.s.x, l2.e.x) >= min(l1.s.x, l1.e.x) &&
5             max(l1.s.y, l1.e.y) >= min(l2.s.y, l2.e.y) &&
6             max(l2.s.y, l2.e.y) >= min(l1.s.y, l1.e.y) &&
7             ((l2.s - l1.s) * (l1.e - l1.s)) * ((l2.e - l1.s) * (l1.e - l1.s)) <= 0 &&
8             ((l1.s - l2.s) * (l2.e - l2.s)) * ((l1.e - l2.s) * (l2.e - l2.s)) <= 0);
9 }

```

### 7.1.7 求解: 点到线最近点

```

1 Point NPT(Point P, Line L)
2 {
3     Point result;
4     double a, b, t;
5     a = L.e.x - L.s.x;
6     b = L.e.y - L.s.y;
7     t = ((P.x - L.s.x) * a + (P.y - L.s.y) * b) / (a * a + b * b);
8     //如果t小于0或者大于1,说明最近点在L.s和L.e这条线段之外
9     result.x = L.s.x + a * t;
10    result.y = L.s.y + b * t;
11    return result;
12 }

```

## 7.2 重心



```

1 Point CenterOfPolygon(Point poly[],int n)
2 {
3     Point p, p0, p1, p2, p3;
4     double m, m0;
5     p1 = poly[0];
6     p2 = poly[1];
7     p.x = p.y = m = 0;
8     for (int i = 2; i < n; i++)
9     {
10        p3 = poly[i];
11        p0.x = (p1.x + p2.x + p3.x) / 3.0;
12        p0.y = (p1.y + p2.y + p3.y) / 3.0;
13        m0 = p1.x * p2.y + p2.x * p3.y + p3.x * p1.y - p1.y * p2.x - p2.y * p3.x -
            p3.y * p1.x;
14        if (cmp(m + m0,0.0) == 0)
15            m0 += eps;
16        p.x = (m * p.x + m0 * p0.x) / (m + m0);
17        p.y = (m * p.y + m0 * p0.y) / (m + m0);
18        m = m + m0;
19        p2 = p3;
20    }
21    return p;
22 }

```

### 7.3 KD树

查找某个点距离最近的点，基本思想是每次分治把点分成两部分，建议按照坐标规模决定是垂直划分还是水平划分，查找时先往分到的那一部分查找，然后根据当前最优答案决定是否去另一个区间查找。

```

1 bool Div[MaxN];
2 void BuildKD(int deep,int l, int r, Point p[])\记得备份一下P
3 {
4     if (l > r) return;
5     int mid = l + r >> 1;
6     int minX, minY, maxX, maxY;
7     minX = min_element(p + l, p + r + 1, cmpX)->x;
8     minY = min_element(p + l, p + r + 1, cmpY)->y;
9     maxX = max_element(p + l, p + r + 1, cmpX)->x;
10    maxY = max_element(p + l, p + r + 1, cmpY)->y;
11    Div[mid] = (maxX - minX >= maxY - minY);
12    nth_element(p + l, p + mid, p + r + 1, Div[mid] ? cmpX : cmpY);
13    BuildKD(l, mid - 1, p);
14    BuildKD(mid + 1, r, p);
15 }
16
17 long long res;
18 void Find(int l, int r, Point a, Point p[])\查找
19 {
20     if (l > r) return;
21     int mid = l + r >> 1;
22     long long dist = dist2(a, p[mid]);
23     if (dist > 0)//如果有重点不能这样判断
24         res = min(res, dist);
25     long long d = Div[mid] ? (a.x - p[mid].x) : (a.y - p[mid].y);
26     int l1, l2, r1, r2;
27     l1 = l, l2 = mid + 1;
28     r1 = mid - 1, r2 = r;
29     if (d > 0)
30         swap(l1, l2), swap(r1, r2);
31     Find(l1, r1, a, p);
32     if (d * d < res)
33         Find(l2, r2, a, p);
34 }

```

### 7.3.1 例题

查询一个点为中心的给定正方形内所有点并删除（2012金华网赛A）

```
1  #include <iostream>
2  #include <cstdio>
3  #include <cstring>
4  #include <algorithm>
5  #include <cmath>
6  #include <queue>
7  using namespace std;
8
9  const int MaxN = 100000;
10 struct Point
11 {
12     int x,y,r;
13     int id;
14     bool del;
15 };
16
17 int cmpTyp;
18 bool cmp(const Point& a,const Point& b)
19 {
20     if (cmpTyp == 0)
21         return a.x < b.x;
22     else
23         return a.y < b.y;
24 }
25
26 int cnt[MaxN];
27 bool Div[MaxN];
28 int minX[MaxN],minY[MaxN],maxX[MaxN],maxY[MaxN];
29 void BuildKD(int l,int r,Point p[])
30 {
31     if (l > r) return;
32     int mid = l+r>>1;
33     cmpTyp = 0;
34     minX[mid] = min_element(p+l,p+r+1,cmp)->x;
35     maxX[mid] = max_element(p+l,p+r+1,cmp)->x;
36     cmpTyp = 1;
37     minY[mid] = min_element(p+l,p+r+1,cmp)->y;
38     maxY[mid] = max_element(p+l,p+r+1,cmp)->y;
39
40     cnt[mid] = r-l+1;
41     cmpTyp = Div[mid] = (maxX[mid]-minX[mid] < maxY[mid]-minY[mid]);
42     nth_element(p+l,p+mid,p+r+1,cmp);
43     BuildKD(l,mid-1,p);
44     BuildKD(mid+1,r,p);
45 }
46
47 queue<int> Q;
48 int Find(int l,int r,Point a,Point p[])
49 {
50     if (l > r) return 0;
51     int mid = l+r>>1;
52     if (cnt[mid] == 0) return 0;
53
54     if (maxX[mid] < a.x-a.r ||
55         minX[mid] > a.x+a.r ||
56         maxY[mid] < a.y-a.r ||
57         minY[mid] > a.y+a.r)
58         return 0;
59 }
```

```

60     int totdel = 0;
61
62     if (p[mid].del == false)
63         if (abs(p[mid].x-a.x) <= a.r && abs(p[mid].y-a.y) <= a.r)
64             {
65                 p[mid].del = true;
66                 Q.push(p[mid].id);
67                 totdel++;
68             }
69
70     totdel += Find(l,mid-1,a,p);
71     totdel += Find(mid+1,r,a,p);
72
73     cnt[mid] -= totdel;
74
75     return totdel;
76 }
77
78 Point p[MaxN],tp[MaxN];
79 int n;
80
81 int main()
82 {
83     int cas = 1;
84     while (true)
85     {
86         scanf("%d",&n);
87         if (n == 0) break;
88
89         for (int i = 0;i < n;i++)
90         {
91             p[i].id = i;
92             int tx,ty;
93             scanf("%d%d%d",&tx,&ty,&p[i].r);
94             p[i].x = tx-ty;
95             p[i].y = tx+ty;
96             p[i].del = false;
97             tp[i] = p[i];
98         }
99         BuildKD(0,n-1,tp);
100
101         printf("Case_#%d:\n",cas++);
102         int q;
103         scanf("%d",&q);
104         for (int i = 0;i < q;i++)
105         {
106             int id;
107             scanf("%d",&id);
108             int res = 0;
109             id--;
110             Q.push(id);
111             while (!Q.empty())
112             {
113                 int now = Q.front();
114                 Q.pop();
115                 if (p[now].del == true) continue;
116                 p[now].del = true;
117                 res += Find(0,n-1,p[now],tp);
118             }
119             printf("%d\n",res);
120         }
121     }
122     return 0;

```

## 7.4 半平面交

直线左边代表有效区域。

```

1 bool HPIcmp(Line a, Line b)
2 {
3     if (fabs(a.k - b.k) > eps) return a.k < b.k;
4     return ((a.s - b.s) * (b.e - b.s)) < 0;
5 }
6
7 Line Q[100];
8 void HPI(Line line[], int n, Point res[], int &resn)
9 {
10     int tot = n;
11     sort(line, line + n, HPIcmp);
12     tot = 1;
13     for (int i = 1; i < n; i++)
14         if (fabs(line[i].k - line[i - 1].k) > eps)
15             line[tot++] = line[i];
16     int head = 0, tail = 1;
17     Q[0] = line[0];
18     Q[1] = line[1];
19     resn = 0;
20     for (int i = 2; i < tot; i++)
21     {
22         if (fabs((Q[tail].e - Q[tail].s) * (Q[tail - 1].e - Q[tail - 1].s)) <
23             eps ||
24             fabs((Q[head].e - Q[head].s) * (Q[head + 1].e - Q[head + 1].s))
25                 < eps)
26             return;
27         while (head < tail && (((Q[tail] & Q[tail - 1]) - line[i].s) * (line[i].e - line[i].s)) > eps)
28             tail--;
29         while (head < tail && (((Q[head] & Q[head + 1]) - line[i].s) * (line[i].e - line[i].s)) > eps)
30             head++;
31         Q[++tail] = line[i];
32     }
33     while (head < tail && (((Q[tail] & Q[tail - 1]) - Q[head].s) * (Q[head].e - Q[head].s)) > eps)
34         tail--;
35     while (head < tail && (((Q[head] & Q[head + 1]) - Q[tail].s) * (Q[tail].e - Q[tail].s)) > eps)
36         head++;
37     if (tail <= head + 1) return;
38     for (int i = head; i < tail; i++)
39         res[resn++] = Q[i] & Q[i + 1];
40     if (head < tail + 1)
41         res[resn++] = Q[head] & Q[tail];
42 }
```

## 7.5 凸包

得到的凸包按照逆时针方向排序。

```

1 bool GScmp(Point a, Point b)
2 {
3     if (fabs(a.x - b.x) < eps)
4         return a.y < b.y - eps;
5     return a.x < b.x - eps;
6 }
7
```

```

8 void GS(Point p[], int n, Point res[], int &resn)
9 {
10     resn = 0;
11     int top = 0;
12     sort(p, p + n, GScmp);
13     for (int i = 0; i < n;)
14         if (resn < 2 || (res[resn - 1] - res[resn - 2]) * (p[i] - res[resn - 1]) > eps)
15             res[resn++] = p[i++];
16         else
17             --resn;
18     top = resn - 1;
19     for (int i = n - 2; i >= 0;)
20         if (resn < top + 2 || (res[resn - 1] - res[resn - 2]) * (p[i] - res[resn - 1]) > eps)
21             res[resn++] = p[i--];
22         else
23             --resn;
24     resn--;
25     if (resn < 3)    resn = 0;
26 }

```

## 7.6 直线与凸包求交点

复杂度 $O(\log n)$ 。

需要先预处理几个东西。

```

1 //二分[la,lb]这段区间那条边与line相交
2 int Gao(int la,int lb,Line line)
3 {
4     if (la > lb)
5         lb += n;
6     int l = la,r = lb,mid;
7     while (l < r)
8     {
9         mid = l+r+1>>1;
10        if (cmp((line.e-line.s)*(p[la]-line.s),0)*cmp((line.e-line.s)*(p[mid]-line.s),0) >= 0)
11            l = mid;
12        else
13            r = mid-1;
14    }
15    return l%n;
16 }
17 //求l与凸包的交点
18
19 //先调用Gettheta预处理出凸包每条边的斜率，然后处理成升序排列
20 double theta[maxn];
21
22 void Gettheta()
23 {
24     for (int i = 0;i < n;i++)
25     {
26         Point v = p[(i+1)%n]-p[i];
27         theta[i] = atan2(v.y,v.x);
28     }
29     for (int i = 1;i < n;i++)
30         if (theta[i-1] > theta[i]+eps)
31             theta[i] += 2*pi;
32 }
33
34 double Calc(Line l)

```

```

35 {
36     double tnow;
37     Point v = l.e-l.s;
38     tnow = atan2(v.y,v.x);
39     if (cmp(tnow,theta[0]) < 0)        tnow += 2*pi;
40     int pl = lower_bound(theta,theta+n,tnow)-theta;
41     tnow = atan2(-v.y,-v.x);
42     if (cmp(tnow,theta[0]) < 0)        tnow += 2*pi;
43     int pr = lower_bound(theta,theta+n,tnow)-theta;
44     //pl和pr是在l方向上距离最远的点对
45     pl = pl%n;
46     pr = pr%n;
47
48     if (cmp(v*(p[pl]-l.s),0)*cmp(v*(p[pr]-l.s),0) >= 0)
49         return 0.0;
50
51     int xa = Gao(pl,pr,l);
52     int xb = Gao(pr,pl,l);
53
54     if (xa > xb)        swap(xa,xb);
55     //与[xa,xa+1]和[xb,xb+1]这两条线段相交
56
57     if (cmp(v*(p[xa+1]-p[xa]),0) == 0) return 0.0;
58     if (cmp(v*(p[xb+1]-p[xb]),0) == 0) return 0.0;
59
60     Point pa,pb;
61     pa = Line(p[xa],p[xa+1])&l;
62     pb = Line(p[xb],p[xb+1])&l;
63     //题目: 求直线切凸包得到的两部分的面积
64     double area0 = sum[xb]-sum[xa+1]+(pa*p[xa+1])/2.0+(p[xb]*pb)/2.0+(pb*pa)
65         /2.0;
66     double area1 = sum[xa+n]-sum[xb+1]+(pb*p[xb+1])/2.0+(p[xa]*pa)/2.0+(pa*
67         pb)/2.0;
68     return min(area0,area1);
69 }

```

## 7.7 三维凸包

暴力写法

```

1  #define eps 1e-7
2  #define MAXV 505
3
4  struct pt
5  {
6      double x, y, z;
7      pt() {}
8      pt(double _x, double _y, double _z): x(_x), y(_y), z(_z) {}
9      pt operator - (const pt p1)
10     {
11         return pt(x - p1.x, y - p1.y, z - p1.z);
12     }
13     pt operator * (pt p)
14     {
15         return pt(y*p.z-z*p.y, z*p.x-x*p.z, x*p.y-y*p.x);
16     }
17     double operator ^ (pt p)
18     {
19         return x*p.x+y*p.y+z*p.z;
20     }
21 };
22 struct _3DCH

```

```

23 {
24     struct fac
25     {
26         int a, b, c;
27         bool ok;
28     };
29     int n;
30     pt P[MAXV];
31     int cnt;
32     fac F[MAXV*8];
33     int to[MAXV][MAXV];
34     double vlen(pt a)
35     {
36         return sqrt(a.x*a.x+a.y*a.y+a.z*a.z);
37     }
38     double area(pt a, pt b, pt c)
39     {
40         return vlen((b-a)*(c-a));
41     }
42     double volume(pt a, pt b, pt c, pt d)
43     {
44         return (b-a)*(c-a)^(d-a);
45     }
46     double ptof(pt &p, fac &f)
47     {
48         pt m = P[f.b]-P[f.a], n = P[f.c]-P[f.a], t = p-P[f.a];
49         return (m * n) ^ t;
50     }
51     void deal(int p, int a, int b)
52     {
53         int f = to[a][b];
54         fac add;
55         if (F[f].ok)
56         {
57             if (ptof(P[p], F[f]) > eps)
58                 dfs(p, f);
59             else
60             {
61                 add.a = b, add.b = a, add.c = p, add.ok = 1;
62                 to[p][b] = to[a][p] = to[b][a] = cnt;
63                 F[cnt++] = add;
64             }
65         }
66     }
67     void dfs(int p, int cur)
68     {
69         F[cur].ok = 0;
70         deal(p, F[cur].b, F[cur].a);
71         deal(p, F[cur].c, F[cur].b);
72         deal(p, F[cur].a, F[cur].c);
73     }
74     bool same(int s, int t)
75     {
76         pt &a = P[F[s].a], &b = P[F[s].b], &c = P[F[s].c];
77         return fabs(volume(a, b, c, P[F[t].a])) < eps && fabs(volume(a, b, c
78             ,
79             P[F[t].b])) < eps && fabs(volume(a, b, c, P[F[t].c])) < eps;
80     }
81     void construct()
82     {
83         cnt = 0;
84         if (n < 4)
85             return;

```

```

85     bool sb = 1;
86     for (int i = 1; i < n; i++)
87     {
88         if (vlen(P[0] - P[i]) > eps)
89         {
90             swap(P[1], P[i]);
91             sb = 0;
92             break;
93         }
94     }
95     if (sb) return;
96     sb = 1;
97     for (int i = 2; i < n; i++)
98     {
99         if (vlen((P[0] - P[1]) * (P[1] - P[i])) > eps)
100        {
101            swap(P[2], P[i]);
102            sb = 0;
103            break;
104        }
105    }
106    if (sb) return;
107    sb = 1;
108    for (int i = 3; i < n; i++)
109    {
110        if (fabs((P[0] - P[1]) * (P[1] - P[2]) ^ (P[0] - P[i])) > eps)
111        {
112            swap(P[3], P[i]);
113            sb = 0;
114            break;
115        }
116    }
117    if (sb) return;
118    fac add;
119    for (int i = 0; i < 4; i++)
120    {
121        add.a = (i+1)%4, add.b = (i+2)%4, add.c = (i+3)%4, add.ok = 1;
122        if (ptof(P[i], add) > 0)
123            swap(add.b, add.c);
124        to[add.a][add.b] = to[add.b][add.c] = to[add.c][add.a] = cnt;
125        F[cnt++] = add;
126    }
127    for (int i = 4; i < n; i++)
128    {
129        for (int j = 0; j < cnt; j++)
130        {
131            if (F[j].ok && ptof(P[i], F[j]) > eps)
132            {
133                dfs(i, j);
134                break;
135            }
136        }
137    }
138    int tmp = cnt;
139    cnt = 0;
140    for (int i = 0; i < tmp; i++)
141    {
142        if (F[i].ok)
143        {
144            F[cnt++] = F[i];
145        }
146    }
147    }

```



```

148 //表面积
149 double area()
150 {
151     double ret = 0.0;
152     for (int i = 0; i < cnt; i++)
153     {
154         ret += area(P[F[i].a], P[F[i].b], P[F[i].c]);
155     }
156     return ret / 2.0;
157 }
158 //体积
159 double volume()
160 {
161     pt O(0, 0, 0);
162     double ret = 0.0;
163     for (int i = 0; i < cnt; i++)
164     {
165         ret += volume(O, P[F[i].a], P[F[i].b], P[F[i].c]);
166     }
167     return fabs(ret / 6.0);
168 }
169 //表面三角形数
170 int facetCnt_tri()
171 {
172     return cnt;
173 }
174 //表面多边形数
175 int facetCnt()
176 {
177     int ans = 0;
178     for (int i = 0; i < cnt; i++)
179     {
180         bool nb = 1;
181         for (int j = 0; j < i; j++)
182         {
183             if (same(i, j))
184             {
185                 nb = 0;
186                 break;
187             }
188         }
189         ans += nb;
190     }
191     return ans;
192 }
193
194 pt Fc[MAXV*8];
195 double V[MAXV*8];
196 pt Center()//重心
197 {
198     pt O(0,0,0);
199     for (int i = 0; i < cnt; i++)
200     {
201         Fc[i].x = (O.x+P[F[i].a].x+P[F[i].b].x+P[F[i].c].x)/4.0;
202         Fc[i].y = (O.y+P[F[i].a].y+P[F[i].b].y+P[F[i].c].y)/4.0;
203         Fc[i].z = (O.z+P[F[i].a].z+P[F[i].b].z+P[F[i].c].z)/4.0;
204         V[i] = volume(O,P[F[i].a],P[F[i].b],P[F[i].c]);
205     }
206     pt res = Fc[0],tmp;
207     double m = V[0];
208     for (int i = 1; i < cnt; i++)
209     {
210         if (fabs(m+V[i]) < eps)

```

```

211         V[i] += eps;
212         tmp.x = (m*res.x+V[i]*Fc[i].x)/(m+V[i]);
213         tmp.y = (m*res.y+V[i]*Fc[i].y)/(m+V[i]);
214         tmp.z = (m*res.z+V[i]*Fc[i].z)/(m+V[i]);
215         m += V[i];
216         res = tmp;
217     }
218     return res;
219 }
220 };
221
222 _3DCH hull;
223
224 int main()
225 {
226     while (scanf("%d",&hull.n) != EOF)
227     {
228         for (int i = 0; i < hull.n; i++)
229             scanf("%lf%lf%lf",&hull.P[i].x,&hull.P[i].y,&hull.P[i].z);
230         hull.construct();
231     }
232     return 0;
233 }

```

## 7.8 旋转卡壳

“对踵”

### 7.8.1 单个凸包

```

1 void solve(Point p[],int n)
2 {
3     Point v;
4     int cur = 1;
5     for (int i = 0;i < n;i++)
6     {
7         v = p[i]-p[(i+1)%n];
8         while (v*(p[(cur+1)%n]-p[cur]) < 0)
9             cur = (cur+1)%n;
10        //p[cur] -> p[i]
11        //p[cur] -> p[i+1]
12        //p[cur] -> (p[i],p[i+1])
13    }
14 }

```

### 7.8.2 两个凸包

注意初始点的选取，代码只是个示例。

有时候答案需要取solve(p0,n,p1,m)和solve(p1,m,p0,n)的最优值。

```

1 void solve(Point p0[],int n,Point p1[],int m)
2 {
3     Point v;
4     int cur = 0;
5     for (int i = 0;i < n;i++)
6     {
7         v = p0[i]-p0[(i+1)%n];
8         while (v*(p1[(cur+1)%m]-p1[cur]) < 0)
9             cur = (cur+1)%m;
10        //p1[cur] -> p0[i]
11        //p1[cur] -> p0[i+1]
12        //p1[cur] -> (p0[i],p0[i+1])

```

```

13     }
14 }

```

### 7.8.3 外接矩形

```

1 void solve()
2 {
3     resa = resb = 1e100;
4     double dis1,dis2;
5     Point xp[4];
6     Line l[4];
7     int a,b,c,d;
8     int sa,sb,sc,sd;
9     a = b = c = d = 0;
10    sa = sb = sc = sd = 0;
11    Point va,vb,vc,vd;
12    for (a = 0; a < n; a++)
13    {
14        va = Point(p[a],p[(a+1)%n]);
15        vc = Point(-va.x,-va.y);
16        vb = Point(-va.y,va.x);
17        vd = Point(-vb.x,-vb.y);
18        if (sb < sa)
19        {
20            b = a;
21            sb = sa;
22        }
23        while (xmult(vb,Point(p[b],p[(b+1)%n])) < 0)
24        {
25            b = (b+1)%n;
26            sb++;
27        }
28        if (sc < sb)
29        {
30            c = b;
31            sc = sb;
32        }
33        while (xmult(vc,Point(p[c],p[(c+1)%n])) < 0)
34        {
35            c = (c+1)%n;
36            sc++;
37        }
38        if (sd < sc)
39        {
40            d = c;
41            sd = sc;
42        }
43        while (xmult(vd,Point(p[d],p[(d+1)%n])) < 0)
44        {
45            d = (d+1)%n;
46            sd++;
47        }
48
49        //卡在p[a],p[b],p[c],p[d上]
50        sa++;
51    }
52 }

```

## 7.9 三角形内点个数

### 7.9.1 无三点共线

```

1 Point p[1000], tp[2000], base;

```

```

2
3 bool cmp(const Point &a, const Point &b)
4 {
5     return a.theta < b.theta;
6 }
7
8 int cnt[1000][1000];
9 int cntleft[1000][1000];
10 int n, m;
11
12 int calc(int a, int b, int c)
13 {
14     Point p1 = p[b] - p[a], p2 = p[c] - p[a];
15     if (atan2(p1.y, p1.x) > atan2(p2.y, p2.x))
16         swap(b, c);
17     if ((p[b] - p[a]) * (p[c] - p[a]) > 0)
18         return cnt[a][c] - cnt[a][b] - 1;
19     else
20         return n - 3 - (cnt[a][c] - cnt[a][b] - 1);
21 }
22
23 int main(int argc, char const *argv[])
24 {
25     int totcas;
26     scanf("%d", &totcas);
27     for (int cas = 1; cas <= totcas; ++cas)
28     {
29         scanf("%d", &n);
30         for (int i = 0; i < n; ++i)
31         {
32             scanf("%lld%lld", &p[i].x, &p[i].y);
33             p[i].id = i;
34         }
35         for (int i = 0; i < n; ++i)
36         {
37             m = 0;
38             base = p[i];
39             for (int j = 0; j < n; ++j)
40                 if (i != j)
41                 {
42                     tp[m] = p[j];
43                     Point v = tp[m] - base;
44                     tp[m++].theta = atan2(v.y, v.x);
45                 }
46
47             sort(tp, tp + m, cmp);
48             for (int j = 0; j < m; ++j)
49                 tp[m + j] = tp[j];
50
51             //calc cnt
52             for (int j = 0; j < m; ++j)
53                 cnt[i][tp[j].id] = j;
54
55             //calc cntleft
56             for (int j = 0, k = 0, tot = 0; j < m; ++j)
57             {
58                 while (k == j || (k < j + m && (tp[j] - base) * (tp[k] -
59                     base) > 0))
60                     k++, tot++;
61                 cntleft[i][tp[j].id] = --tot;
62             }
63     }

```

```

64         printf("Case□%d:\n", cas);
65         int q;
66         scanf("%d", &q);
67         for (int i = 0; i < q; ++i)
68         {
69             int x, y, z;
70             scanf("%d%d%d", &x, &y, &z);
71             if ((p[z] - p[x]) * (p[y] - p[x]) > 0)
72                 swap(y, z);
73             int res = cntleft[x][z] + cntleft[z][y] + cntleft[y][x];
74             res += calc(x, y, z) + calc(y, z, x) + calc(z, x, y);
75             res -= 2 * (n - 3);
76             printf("%d\n", res);
77         }
78     }
79     return 0;
80 }

```

### 7.9.2 有三点共线且点有类别之分

```

1  int n,n0,n1,m;
2  Point p[3000], tp[3000], base;
3
4  bool cmp(const Point &a, const Point &b)
5  {
6      if ((a-base)*(b-base) == 0)
7      {
8          return (a-base).getMol() < (b-base).getMol();
9      }
10     return a.theta < b.theta;
11 }
12
13 int cnt[100][100];
14 int cntleft[100][100];
15
16 int calc(int a,int b,int c)
17 {
18     Point p1 = p[b]-p[a],p2 = p[c]-p[a];
19     if (atan2(1.0*p1.y,1.0*p1.x) > atan2(1.0*p2.y,1.0*p2.x))
20         swap(b,c);
21     int res = cnt[a][c]-cnt[a][b];
22     if ((p[b]-p[a])*(p[c]-p[a]) > 0)
23         return res;
24     else
25         return n1-res;
26 }
27
28 int main()
29 {
30     int cas = 0;
31     while (scanf("%d%d",&n0,&n1) != EOF)
32     {
33         n = n1+n0;
34         for (int i = 0; i < n; i++)
35         {
36             scanf("%I64d%I64d",&p[i].x,&p[i].y);
37             p[i].id = i;
38         }
39         for (int i = 0; i < n0; ++i)
40         {
41             m = 0;
42             base = p[i];
43             for (int j = 0; j < n; ++j)
44                 if (i != j)

```

```

45         {
46             tp[m] = p[j];
47             Point v = tp[m]-base;
48             tp[m++].theta = atan2(1.0*v.y,1.0*v.x);
49         }
50
51     sort(tp, tp + m, cmp);
52     for (int j = 0; j < m; ++j)
53         tp[m + j] = tp[j];
54
55     for (int j = 0, tot = 0; j < m; ++j)
56     {
57         if (tp[j].id < n0)
58             cnt[i][tp[j].id] = tot;
59         else
60             tot++;
61     }
62
63     for (int j = 0, k = 0, tot = 0; j < m; ++j)
64     {
65         while (k == j || (k < j + m && (tp[j] - base) * (tp[k] -
66             base) > 0))
67         {
68             if (tp[k].id >= n0)
69                 tot++;
70             k++;
71         }
72         if (tp[j].id >= n0)
73             tot--;
74         else
75             cntleft[i][tp[j].id] = tot;
76     }
77
78     int ans = 0;
79     for (int i = 0; i < n0; i++)
80         for (int j = i+1; j < n0; j++)
81             for (int k = j+1; k < n0; k++)
82             {
83                 int x = i, y = j, z = k;
84
85                 if ((p[z] - p[x]) * (p[y] - p[x]) > 0)
86                     swap(y, z);
87                 int res = cntleft[x][z] + cntleft[z][y] + cntleft[y][x];
88
89                 res += calc(x, y, z) + calc(y, z, x) + calc(z, x, y);
90
91                 res -= 2 * n1;
92
93                 //printf("%d %d %d %d\n", x, y, z, res);
94
95                 if (res%2 == 1)
96                     ans++;
97             }
98     printf("Case %d: %d\n", ++cas, ans);
99 }
100 return 0;
101 }

```

## 8 搜索

### 8.1 Dancing Links

仰慕罗神。

```
1 void remove1(int col)
2 {
3     int i,j;
4     L[R[col]]=L[col];
5     R[L[col]]=R[col];
6     for(i=D[col];i!=col;i=D[i])
7     {
8         L[R[i]]=L[i];
9         R[L[i]]=R[i];
10    }
11 }
12 void remove2(int col)
13 {
14     int i,j;
15     L[R[col]]=L[col];
16     R[L[col]]=R[col];
17     for(i=D[col];i!=col;i=D[i])
18     {
19         for(j=R[i];j!=i;j=R[j])
20         {
21             U[D[j]]=U[j];
22             D[U[j]]=D[j];
23             --nk[C[j]];
24         }
25     }
26 }
27 void resume1(int col)
28 {
29     int i,j;
30     for(i=U[col];i!=col;i=U[i])
31     {
32         L[R[i]]=i;
33         R[L[i]]=i;
34     }
35     L[R[col]]=col;
36     R[L[col]]=col;
37 }
38 void resume2(int col)
39 {
40     int i,j;
41     for(i=U[col];i!=col;i=U[i])
42     {
43         for(j=L[i];j!=i;j=L[j])
44         {
45             ++nk[C[j]];
46             U[D[j]]=j;
47             D[U[j]]=j;
48         }
49     }
50     L[R[col]]=col;
51     R[L[col]]=col;
52 }
53 int h()
54 {
55     bool vis[100];
56     memset(vis,false,sizeof(vis));
57     int i,j,k,res=0,mi,col;
```

```

58 while(1)
59 {
60     mi=inf;
61     for(i=R[head]; i!=head&& i<=2*n; i=R[i])
62         if(mi>nk[i]&&!vis[i])
63         {
64             mi=nk[i];
65             col=i;
66         }
67     if(mi==inf)
68         break;
69     res++;vis[col]=true;
70     for(j=D[col]; j!=col; j=D[j])
71         for(k=R[j]; k!=j; k=R[k])
72         {
73             if(C[k]>2*n)
74                 continue;
75             vis[C[k]]=true;
76         }
77 }
78 return res;
79 }
80 bool DLX(int d,int deep)
81 {
82     if(d+h(>deep) return false;
83     if(R[head]==head||R[head]>2*n)
84         return true;
85     if(d>=deep)
86         return false;
87     int col,ma=inf;
88     int i,j;
89     for(i=R[head]; i!=head&& i<=2*n; i=R[i])
90         if(nk[i]<ma)
91         {
92             col=i;
93             ma=nk[i];
94         }
95     remove1(col);
96     for(i=D[col]; i!=col; i=D[i])
97     {
98         int flag=1;
99         for(j=R[i]; j=R[j])
100         {
101             if(j==R[i]&&!flag)
102                 break;
103             U[D[j]]=U[j];
104             D[U[j]]=D[j];
105             if(C[j]>2*n)
106                 remove2(C[j]);
107             else
108                 remove1(C[j]);
109             flag=0;
110         }
111         if(DLX(d+1,deep))
112             return true;
113         flag=1;
114         for(j=L[i]; j=L[j])
115         {
116             if(j==L[i]&&!flag)
117                 break;
118             if(C[j]>2*n)
119                 resume2(C[j]);
120             else

```



```

121         resume1(C[j]);
122         U[D[j]]=j;
123         D[U[j]]=j;
124         flag=0;
125     }
126 }
127 resume1(col);
128 return false;
129 }

```

## 9 杂物

### 9.1 高精度数

支持乘以整数和加法。

```
1 struct BigInt
2 {
3     const static int mod = 1000000000;
4     int a[600], len;
5     BigInt () {}
6     BigInt (int v)
7     {
8         len = 0;
9         do
10        {
11            a[len++] = v%mod;
12            v /= mod;
13        }while(v);
14    }
15     BigInt operator *(const int& b) const
16     {
17         BigInt res;
18         res.len = len;
19         for (int i = 0; i <= len; ++i)
20             res.a[i] = 0;
21         for (int i = 0; i < len; ++i)
22         {
23             res.a[i] += a[i]*b;
24             res.a[i+1] += res.a[i]/mod;
25             res.a[i] %= mod;
26         }
27         if (res.a[len] > 0) res.len++;
28         return res;
29     }
30     BigInt operator +(const BigInt& b) const
31     {
32         BigInt res;
33         res.len = max(len, b.len);
34         for (int i = 0; i <= res.len; ++i)
35             res.a[i] = 0;
36         for (int i = 0; i < res.len; ++i)
37         {
38             res.a[i] += ((i < len)?a[i]:0)+((i < b.len)?b.a[i]:0);
39             res.a[i+1] += res.a[i]/mod;
40             res.a[i] %= mod;
41         }
42         if (res.a[res.len] > 0) res.len++;
43         return res;
44     }
45     void output()
46     {
47         printf("%d", a[len-1]);
48         for (int i = len-2; i >= 0; --i)
49             printf("%08d", a[i]);
50         printf("\n");
51     }
52 };
```

### 9.2 整数外挂

```
1 int wg;
```

```

2 char ch;
3 bool ng;
4
5 inline int readint()
6 {
7     ch = getchar();
8     while (ch != '-' && (ch < '0' || ch > '9')) ch = getchar();
9     if (ch == '-')
10    {
11        ng = true;
12        ch = getchar();
13    }
14    else
15        ng = false;
16    wg = ch-'0';
17    ch = getchar();
18    while (ch >= '0' && ch <= '9')
19    {
20        wg = wg*10+ch-'0';
21        ch = getchar();
22    }
23    if (ng == true) wg = -wg;
24    return wg;
25 }

```

## 9.3 Java

### 9.3.1 优先队列

```

1 PriorityQueue queue = new PriorityQueue( 1, new Comparator()
2 {
3     public int compare( Point a, Point b )
4     {
5         if( a.x < b.x || a.x == b.x && a.y < b.y )
6             return -1;
7         else if( a.x == b.x && a.y == b.y )
8             return 0;
9         else
10            return 1;
11    }
12 });

```

### 9.3.2 Map

```

1 Map map = new HashMap();
2 map.put("sa","dd");
3 String str = map.get("sa").toString;
4
5 for(Object obj : map.keySet()){
6     Object value = map.get(obj );
7 }

```

### 9.3.3 sort

```

1 static class cmp implements Comparator
2 {
3     public int compare(Object o1, Object o2)
4     {
5         BigInteger b1=(BigInteger)o1;
6         BigInteger b2=(BigInteger)o2;
7         return b1.compareTo(b2);
8     }
9 }
10 public static void main(String[] args) throws IOException
11 {

```

```

12     Scanner cin = new Scanner(System.in);
13     int n;
14     n=cin.nextInt();
15     BigInteger[] seg = new BigInteger[n];
16     for (int i=0;i<n;i++)
17     seg[i]=cin.nextBigInteger();
18     Arrays.sort(seg,new cmp());
19 }

```

## 9.4 hashmap

```

1 struct hash_map
2 {
3     const static int mod=10007;
4     int head[mod];
5     struct hash_tables
6     {
7         int key;
8         int val;
9         int next;
10    } ele[10007];
11    int N;
12    int getHash(int x)
13    {
14        return x%mod;
15    }
16    void init()
17    {
18        memset(head,255,sizeof(head));
19        N=0;
20    }
21    void clear()
22    {
23        for (int i = 0; i < N; i++)
24            head[getHash(ele[i].key)] = -1;
25        N = 0;
26    }
27    int fint(int x)
28    {
29        for (int i=head[getHash(x)]; i!=-1; i=ele[i].next)
30            if (ele[i].key==x) return i;
31        return -1;
32    }
33    void insert(int x)
34    {
35        int tmp=getHash(x);
36        ele[N].key=x;
37        ele[N].val=0;
38        ele[N].next=head[tmp];
39        head[tmp]=N++;
40    }
41    int& operator [](int x)
42    {
43        int tmp=fint(x);
44        if (tmp==-1)
45        {
46            insert(x);
47            return ele[N-1].val;
48        }
49        else
50            return ele[tmp].val;
51    }
52 };

```